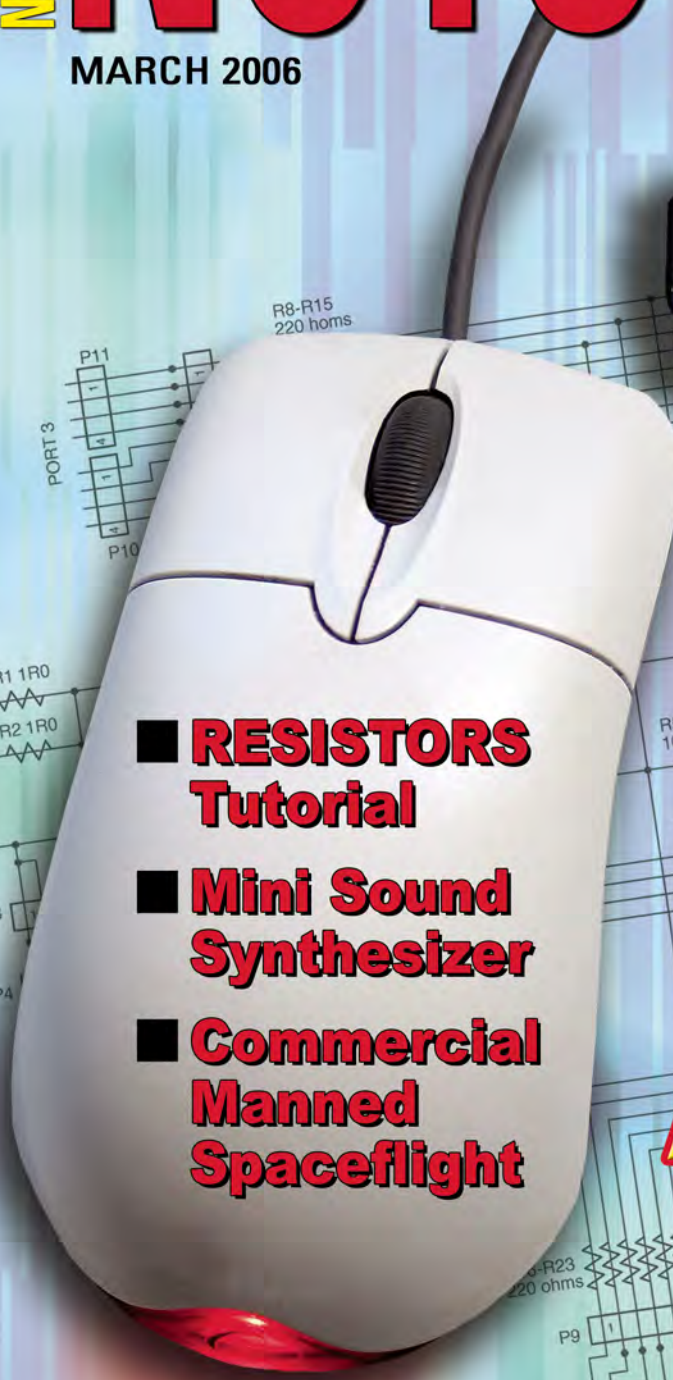


NUTS AND VOLTS

MARCH 2006

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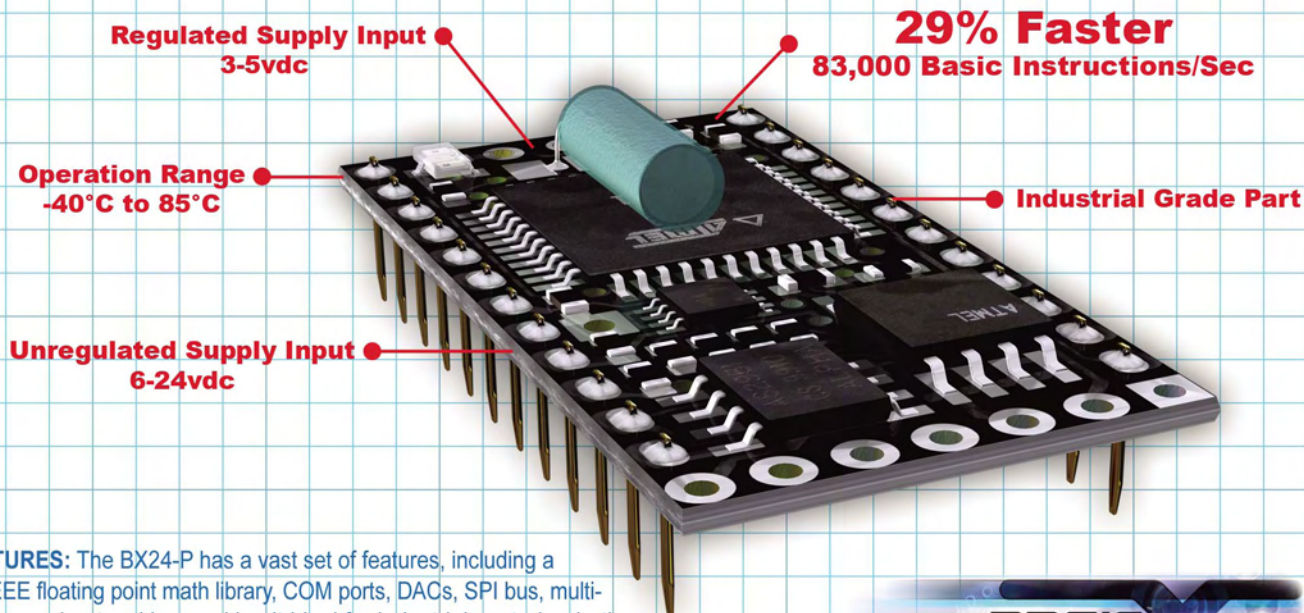
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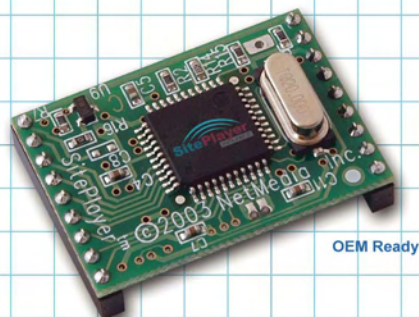
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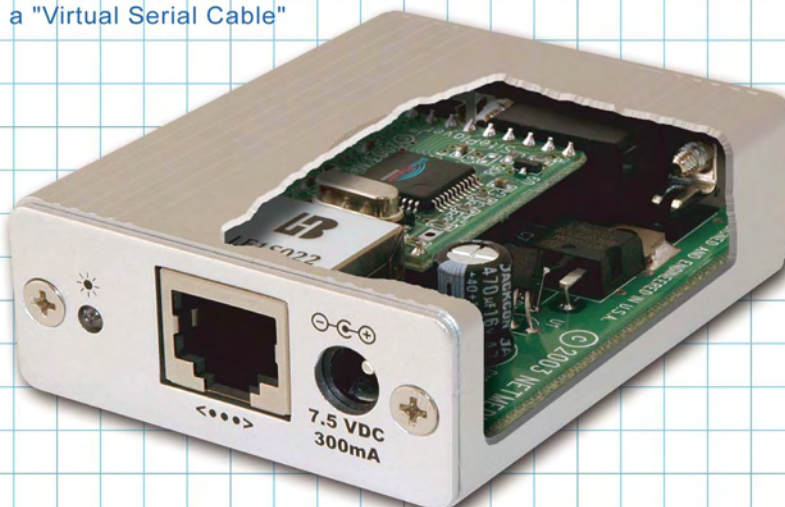


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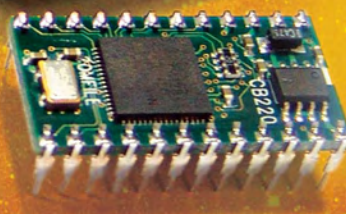
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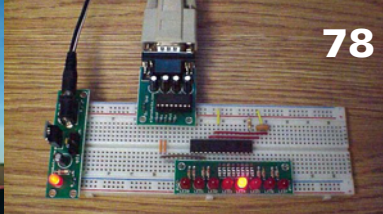
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NUTS AND VOLTS

MARCH 2006

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Easily incorporate the power of your PC into any project.

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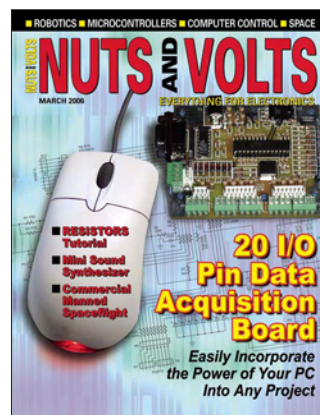
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Nuts & Volts (ISSN 1528-9885/CDN Pub Agree#40702530) is published monthly for \$24.95 per year by T & L Publications, Inc., 430 Princeland Court, Corona, CA 92879. PERIODICALS POSTAGE PAID AT CORONA, CA AND AT ADDITIONAL MAILING OFFICES. POSTMASTER: Send address changes to **Nuts & Volts, P.O. Box 15277, North Hollywood, CA 91615** or Station A, P.O. Box 54, Windsor ON N9A 6J5; cpcreturns@nutsvolts.com



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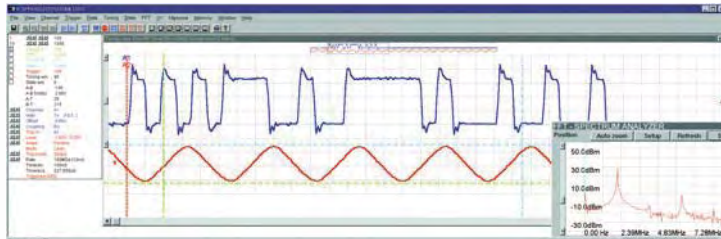
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READER FEEDBACK

NUTS AND VOLTS
EVERYTHING FOR ELECTRONICS

RAINDROPS KEEP FALLING ...

I very much enjoyed the article on weather instruments by J. Ronald Eyton. In particular, the application of commonly-available construction items to make useful items. The remote temperature sensors are often put out without any thought to the environmental effects such as solar radiation. Your use of simple plastic shutters made a very nice temperature screen for these sensors. This is the best homemade screen I have seen and it even looks attractive in your garden.

I did have a few comments. The Stevenson screen (1869) is actually a double louvred screen. A single louvred screen like you have constructed is similar to the USWB cotton regions

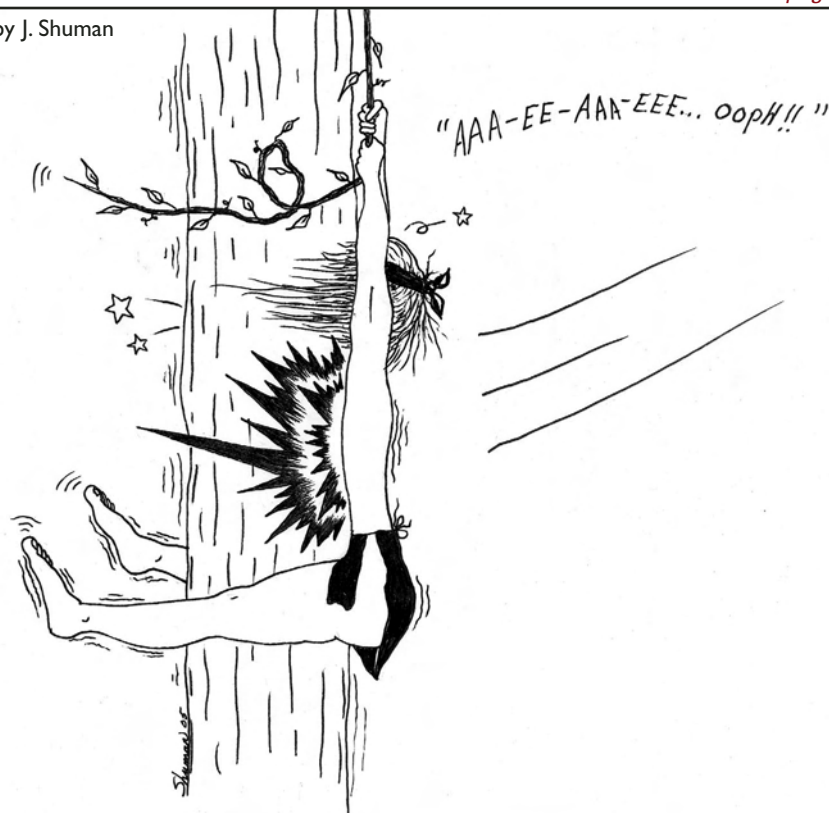
screen. Temperature varies with height and the normal height for temperature sensors should be mounted between 1.25 to 2 meters above the ground.

The "Rain Chime" along with your tipping bucket rain gauge would keep one well aware of the occurrence of any rainfall. This is a simple variation of the distrometer which is usually quite expensive. Another simple version is to use a block of epoxy about 3" in diameter with a piezoelectric element attached to the bottom. Each raindrop produces an output which is proportional to the size of the raindrop. From that information, the total rainfall can be crudely determined ($\pm 30\%$). While an interesting concept, your tipping bucket is more accurate (-5 to -10%). Keep up the good work.

Ken Devine
Aurora, Ontario, Canada

Continued on page 98

by J. Shuman



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P.O. Box 15277

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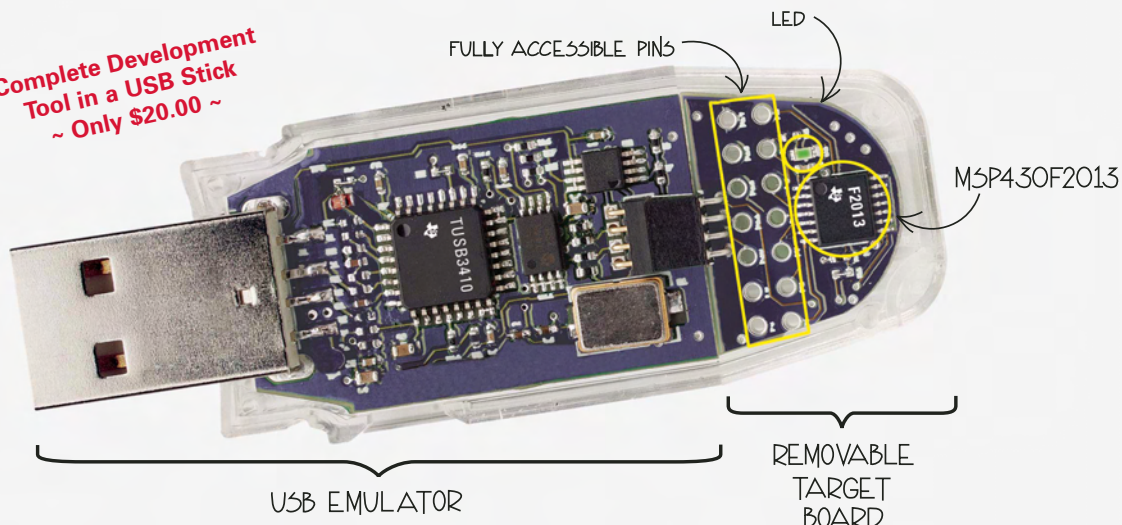
Michele Durant

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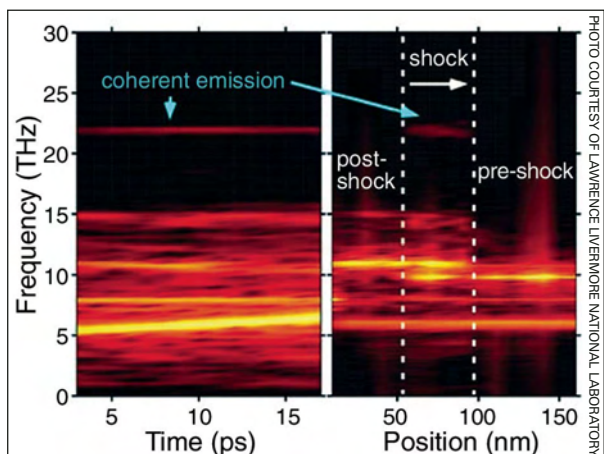
 **TEXAS INSTRUMENTS**



■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

NEW COHERENT LIGHT SOURCE DISCOVERED



■ Emission of coherent light at 22 THz from a molecular dynamics simulation of shocked NaCl (table salt).

For 50 years or so, the only way to generate coherent light has been through the use of a standard or free-electron laser, but researchers from Lawrence Livermore National Laboratory (www.llnl.gov) and the Massachusetts Institute of Technology (www.mit.edu) have discovered that common table salt is capable of emitting light in the range of 1 to 100 THz when subjected to a mechanical shock.

Through a series of theoretical calculations and experimental simulations, scientists generated a mechanical shock wave inside a dielectric crystalline material, in this case NaCl. One would expect to see only incoherent photons and sparks emitted from the shocked crystal, but weak yet measurable coherent light emerged. The emission frequencies are determined by the shock speed and the lattice makeup of the crystal.

In the illustration, the left panel shows the emission of the light as a function of time while the shock is propagating. The right panel shows the generated radiation as a function

of location within the shocked crystal, indicating that the 22 THz coherent signal is generated at the shock front (between the white dotted lines). According to Evan Reed, a postdoctoral fellow at LLNL, applications for this research are numerous, but the most immediate result may be a new diagnostic tool to determine the properties of shock waves.

Coherent light, being very narrow bandwidth radiation, is useful for interferometry (the measurement of two or more waves coming together at the same time and place, such as optical and shock waves). Further experiments will be conducted in collaboration with researchers from the Los Alamos National Laboratory (www.lanl.gov).

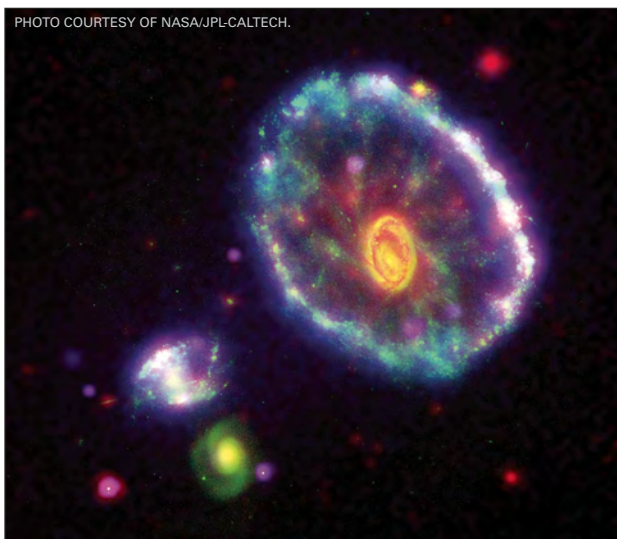
GALEX MAPS OUT THE CARTWHEEL GALAXY

For nearly three years, the Galaxy Evolution Explorer (GALEX)

space telescope has been in orbit, observing galaxies in ultraviolet light in an endeavor to gather 10 billion years of cosmic history. A recent subject of scrutiny is the Cartwheel galaxy, which is of particular interest because, about 100 million years ago, a smaller galaxy plunged through it, creating ripples of star formation.

This is shown in the false-color composite depiction, which is made up of images from the GALAX far-ultraviolet detector (blue), the Hubble Space Telescope's wide field and planetary camera 2 in B-band visible light (green), the Spitzer Space Telescope's infrared array camera at 8 microns (red), and the Chandra X-ray Observatory's advanced CCD imaging spectrometer-S array instrument (purple).

Although astronomers have not identified exactly which galaxy collided with the Cartwheel, two of three candidate galaxies can be seen in this image to the bottom left of the ring—one as a neon blob and the other as a green spiral. For more information about the project and other images, visit www.galex.caltech.edu



WAVEGUIDE CONTROLS SPEED OF LIGHT

Late last year, IBM (www.ibm.com) announced the creation of a tiny device that was described as a major advancement toward the eventual use of light instead of electricity in

■ The GALEX orbiting space telescope contributed to this composite image of the Cartwheel galaxy.

electronic components, potentially leading to vast improvements in the performance of computers and other electronic systems. Apparently, IBM scientists were able to slow light down to less than 1/300th of its usual speed by directing it down a carefully designed channel of perforated silicon called a "photonic crystal waveguide."

Furthermore, the design of the device allows the light's speed to be varied over a wide range simply by applying an electrical voltage to the waveguide. The device's small size, use of standard semiconductor materials, and ability to more closely control this "slow light" could make the technology useful for building ultra-compact optical communications circuits that are practical for integration into computer systems.

The waveguide is a thin slab of silicon punctuated by arrays of holes that scatter light. The pattern and size of the holes gives the material a very high refractive index, and the speed of light passing through it varies inversely with the refractive index. Heating the waveguide locally with a small electrical current alters the refractive index, allowing the speed of light to be tuned over a wide range with very low applied electric power.

According to IBM, the device could be applied to create a variety of nanophotonic components such as optical delay lines, optical buffers, and even optical memory, all of which would be useful in building computer systems that are joined by powerful optical communications networks.

COMPUTERS AND NETWORKING

INTEL-BASED MACS ARRIVE EARLY

Although not originally scheduled to appear for several more months, Apple Computer (www.apple.com) has unveiled two new machines that run the Mac OS® X operat-

ing system on Intel's Core™ Duo processor. The desktop machine looks like the original iMac, which puts the motherboard and other components behind the monitor, thus eliminating a separate box for the CPU.

According to the company, the new iMac delivers up to twice the performance as the previous version, which was based on the PowerPC chip. It includes a built-in iSight™ video camera for video conferencing and new versions of iPhoto®, iMovie®, iDVD®, and GarageBand™, plus a new website creation program called iWeb™.

Standard hardware features include a SuperDrive™ for burning DVDs, 512 MB of 667 MHz DDR2 SDRAM (expandable to 2 GB), a 500 GB hard drive, built-in Ethernet and wireless networking capability, and a range of other amenities. The new iMac starts at \$1,299 for a 1.83 GHz model with a 17-inch LCD display. For \$1,699, you can step up to a 2.0 GHz processor and a 20-inch display.

Also introduced was the MacBook Pro — an Intel-based laptop with a 15.4-inch display and a price tag starting at \$1,999. It is said to be as much as five times as powerful as existing PowerBooks, which, due

to the relatively high power consumption of the G5 chip, never got past the G4 level.

FLASH DRIVES FEATURE FILE DISPLAY

■ Flash drive features display of filenames.

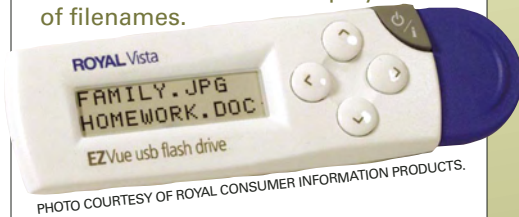


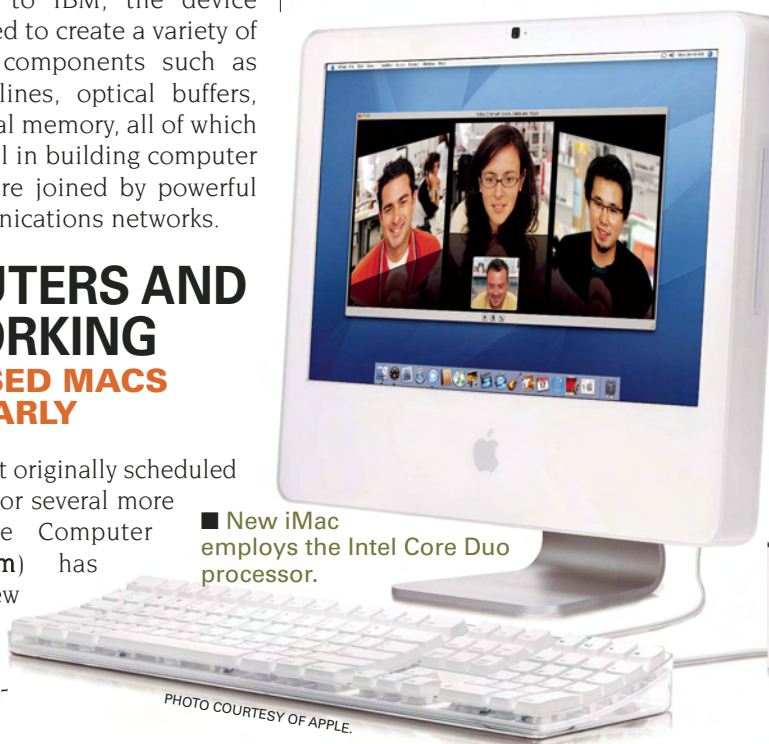
PHOTO COURTESY OF ROYAL CONSUMER INFORMATION PRODUCTS.

Featuring compact size and pretty decent storage capacity, USB 2.0 Flash/jump drives have grown increasingly popular for transporting office files, school notes, music, and other data from one computer to another. But, until recently, there was no way to tell what was stored in the drive unless it was connected to a computer.

A new series of devices from Royal Consumer Information Products (www.royal.com) solves that problem with a built-in, scrolling two-line display. Called the EZVue Vista series, the patent-pending drives allow you to see directories and subdirectories, and scrolling to the right allows you to see the complete file name, extensions, and creation dates. The drives are both PC and Mac compatible and come with capacities ranging from 128 MB to 1 GB and prices from \$49.99 to \$149.99.

NEW SEARCH ENGINE UP AND RUNNING

You're probably thinking, sure, just what the world needs — another search engine. However, Tyloon (www.tyloon.com) has added an interesting twist in that it is multilingual, offering what is billed as the first and only "online yellow pages and local search engine" that allows visitors, using keywords in any of four languages (English, Spanish, simplified Chinese, and traditional Chinese), or mixed keywords



■ New iMac employs the Intel Core Duo processor.

PHOTO COURTESY OF APPLE.

in those languages, to search the same 15-million-name US business database.

According to the company, there are 1.6 billion people speaking Chinese and Spanish all around the world, including nearly 25 percent of the US population. Tyloon's "patent-pending search system" allows visitors to not only browse and/or search listed business information in their own language, but also to freely change the current viewing page to a different language without going to the home page of a language. This is intended to make it much easier for non-English speaking people to obtain and understand information about American businesses.

CIRCUITS AND DEVICES

USB INTERNET SPEAKER PHONE UNVEILED

Introduced at the 2006 Consumer Electronics Show and set to be available by the time you read this is the Skype-certified USR9610 USB Internet Speakerphone from USRobotics (www.usr.com). Featuring echo cancellation technology, volume and mute buttons, and full-duplex operation, the unit works like a traditional speakerphone, but eliminates the costs of a long distance call. The speakerphone is lightweight, making it convenient for business travelers, and it works with free software available from Skype (www.skype.com). The USR9610 lists for \$49.95.

RADIATION-HARDENED CONVERTER INTRODUCED

On the off chance that you plan to

■ The LS series of radiation-hardened DC-DC converters feature an internal EMI filter.

build equipment for use in satellite applications, including low Earth orbit (LEO), middle Earth orbit (MEO), geostationary Earth orbit (GEO), or long scientific missions, you might be particularly interested in the LS series of low-voltage single- and dual-output DC-DC converters from International Rectifier (www.irf.com).

The modules, which include an internal MIL-STD-461C CE03-compliant EMI filter, deliver isolated output voltages from 1.5V to 15.0V, with typical efficiency ratings up to 83 percent. The devices are characterized with a total ionizing dose (TID) of greater than 100K Rad(Si) and single event effect (SEE) linear energy transfer (LET) of heavy ions greater than 82 MeV.cm²/mg, in accordance with MIL-STD-883.

The fixed-frequency, single-ended forward converters switch at 575 kHz. Other features include 18V to 40V input range, magnetically coupled feedback to ensure optimum cross-regulation when the loads are unbalanced, adjustable output voltage, and a device weight of less than 85 g. Of course, the average *Nuts & Volts* reader is pretty unlikely to ever have a need for such a device, but it is somewhat intriguing to know that they cost \$6,500 each. **NV**



INDUSTRY AND THE PROFESSION

HYDROGEN REFUELING STATION PLANNED

If you drive a hydrogen-powered vehicle and live near Minot, ND (about 110 miles from Bismarck), you're in luck. Hydrogenics Corp. (www.hydrogenics.com) recently announced that the company was awarded a contract by Basin Electric Power Cooperative, or Bismarck, to supply an electrolyzer-based hydrogen refueling station for installation in Minot.

In addition to the core electrolyzer module, Hydrogenics is supplying compression, storage, and dispenser equipment as part of the contract. The station, scheduled for installation later this year, will be one of the first United States-based hydrogen fueling stations to use electricity from a wind power resource to produce hydrogen from water, in this case using electricity generated by wind

resources either owned or contracted by Basin Electric.

The hydrogen produced will be used to refuel hydrogen-powered vehicles, demonstrating a linkage between wind power and vehicle refueling. It is intended to demonstrate the ability and practicality of making and using hydrogen energy with zero carbon emissions, using excess wind power that might otherwise be underutilized.

IPOD LOADING SERVICE LAUNCHED

If you have a serious desire to watch full-length movies on your iPod, and if you live in one of the cities where LoadPod (www.loadpod.com) has an office (New York City, Chicago, Fort Lauderdale, Miami, Orlando, Philadelphia, San Francisco, and Seattle), you're in luck. The company will show up at your home and office, load it full of movies that have been encoded into the 320 by 240 display format, and return the iPod to you. The only catch appears to be the price: \$34.95 each if you buy 5 to 10, \$31.95 each for 11 to 20, and \$27.95 each for 21 to 40.

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Solutions That Work

■ BY JON WILLIAMS

WADING THE BS1 DEBUG STREAM

UNTIL RECENTLY, I HAD NEVER REALLY CONSIDERED USING A BS1 as a front-end to a PC program — unlike the BS2, the BS1 doesn't have the ability to do SEROUT on its programming port. But then my colleague, Chuck, had this idea about building a BS1 right into a USB connector. Well, that changes things; now the BS1 is not just connected to the PC, it's nearly a part of it. With no SEROUT on the programming port, it's time to roll up the pant legs and wade through the BS1's DEBUG stream.

For those of you that have been around for a long time, or have taken the time to go back through past issues of this column, you may remember that Scott Edwards tackled this subject back in October of 1996. Scott was able to [correctly] deduce most of the aspects of the BS1 DEBUG stream through empirical observation. I have the advantage of working "on the inside" and, after spending an hour chatting with our compiler engineer, it's my intent to show you how to use the BS1's DEBUG output in your PC projects.

THE DIRT ON BS1 DEBUG

As Scott pointed out, any time you have a DEBUG instruction in a BS1 program, everything (all variables) gets sent to the PC. This may seem odd at first, and yet there is a perfectly logical explanation: the BS1 only has 256 bytes of program memory. As we all know, that's not a lot of space and anything that can be done to conserve it is important. Chip — the BASIC Stamp's inventor — came up with an interesting solution that can be demonstrated with a simple program.

Enter this program in your BASIC Stamp IDE and check the Memory Map:

```
' {$STAMP BS1}
' {$PBASIC 1.0}

SYMBOL count = B2

Main:
  FOR count = 1 TO 10
    DEBUG #count, CR
    PAUSE 300
  NEXT
  GOTO Main
```

If you typed it in just like the listing, you should see that the last location used is \$EF, so the program consumes 17 bytes of EEPROM. Okay, now modify the DEBUG line like this and open the Memory Map again:

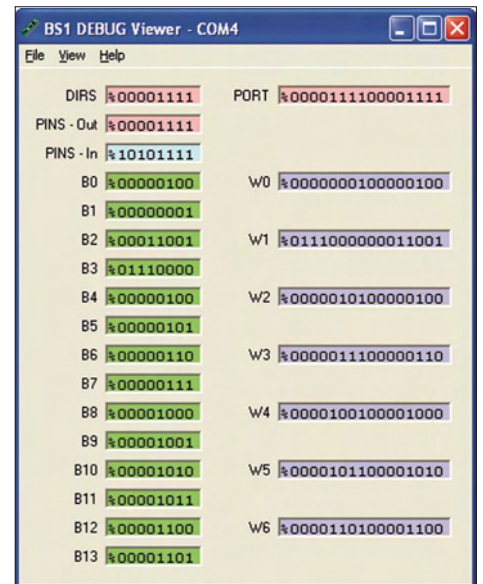
```
' {$STAMP BS1}
' {$PBASIC 1.0}

SYMBOL count = B2

Main:
  FOR count = 1 TO 10
    DEBUG "The value of 'count' is: ", #count, CR
    PAUSE 300
  NEXT
  GOTO Main
```

Again, the last location used \$EF for a program total of 17 bytes. *What the?* ... Interesting, isn't it? Here's the secret: That big string of characters we added to the program does not get stored inside the BS1, it's actually stored in a table inside the BASIC Stamp IDE. The reason for this is that we normally use DEBUG when we're connected to the IDE, so it made more sense to store the strings there rather than in the BS1 where they would very quickly eat through our precious program memory.

When we compile and download a program to our BS1, the editor creates a special table for all the occurrences of DEBUG. The table is indexed by the program counter (location) where the DEBUG instruction is placed. Part of



■ FIGURE 1. BS1 Debug Viewer Program.

the **DEBUG** packet is the program counter. When the editor receives a **DEBUG** packet, it grabs the program counter first and then checks the table to see how that specific **DEBUG** instruction is to be formatted for display.

Okay, let's talk about the **DEBUG** packet. Most of the time, it will be 97 bytes long. The first part of the packet is [usually] 64 bytes — this is for synchronization with the PC, and all the sync bytes are \$F0. Remember that the BS1 was designed long before Windows and the original programming was via bit-banged serial on the PC's printer port (the printer port was used because of its TTL-level I/O, which meant the connection could be simple and direct — no level shifting required). After the sync bytes, we'll find either a \$5A (this is a **DEBUG** packet) or \$A5 (this is a Connect packet). What follows is a 32-byte data dump of the PIC16C56's (host micro) RAM space.

You may be wondering about the Connect packet. If you look at the programming circuit, there are only two lines (serial in and serial out) for programming. Unlike its big brother — the BS2 — the BS1 cannot be reset by the BASIC Stamp IDE. So, what the BS1 does is interleave Connect packets with the **DEBUG** output; when the IDE sees a Connect packet, it can download a new program. This explains why, when programming the BS1, we're occasionally forced to wait a bit — the editor is holding for a Connect packet.

In Scott's article, he said that he had occasional connection errors, and I think the reason why is that the sync section can actually be up to 128 bytes long — though I've not seen this in any of my own experiments. That said, we still have to deal with that if it occurs. Our basic strategy for using the BS1 **DEBUG** output in a PC program is simple: We'll program the BS1 with a **DEBUG** instruction, and then open the serial port used to program the BS1 and collect incoming bytes. Once we have enough bytes to constitute a **DEBUG** packet, we'll look for a bunch of sync bytes followed by \$5A. If we find that, we'll grab the next 32 bytes and parse the variable values out of it. Ready? Let's give it a shot.

BS1 DEBUG TO PC

I'm most comfortable using Visual Basic for my PC programming chores, but if you're using another product (especially REALbasic), you should be able to port this code pretty easy. As with most of my projects, I definitely employ the KISS principle here. The first thing to do, of course, is select an open serial port. One thing to remember is that we can't open a port in use, so after we've downloaded a program to the BS1, we need to close the IDE's Debug Terminal window to free the port. Here's the bit of code that sets up and opens the serial port with VB:

```
With MScmm1
  .CommPort = bs1PortNum
  .DTREnable = True
  .RTSEnable = False
  .Settings = "4800,n,8,1"
  .RThreshold = 1
  .PortOpen = True
End With
```

For those of you using a different language, here's what all that means: We set the port to 4800 baud, N81-style serial, we turn on the DTR line, make sure the RTS line is off, and set the serial object to fire an event any time a character shows up. When you open the full listing, you'll see that the variable called *bs1PortNum* comes from a simple port selection dialog.

With the port open and a BS1 attached, bytes should start streaming in. The serial port **OnComm()** event is really simple.

```
Private Sub MScmm1_OnComm()

  If (MScmm1.InBufferCount >= 97) Then
    bs1Buffer = bs1Buffer & MScmm1.Input
  End If

End Sub
```

As you can see, anytime a character shows up, we check to see if we have enough bytes in the buffer to constitute a valid **DEBUG** packet. If we do, we append the contents of the serial buffer to an internal variable — *bs1Buffer* (a string) — for our processing. Note that this action empties the contents of the PC serial buffer.

Since Visual Basic is event-based, we need some event to fire in order to check the size of *bs1Buffer* to see if it needs processing. Again, let's keep things very simple: We'll use a Timer set to trip every 50 milliseconds when the serial port is open.

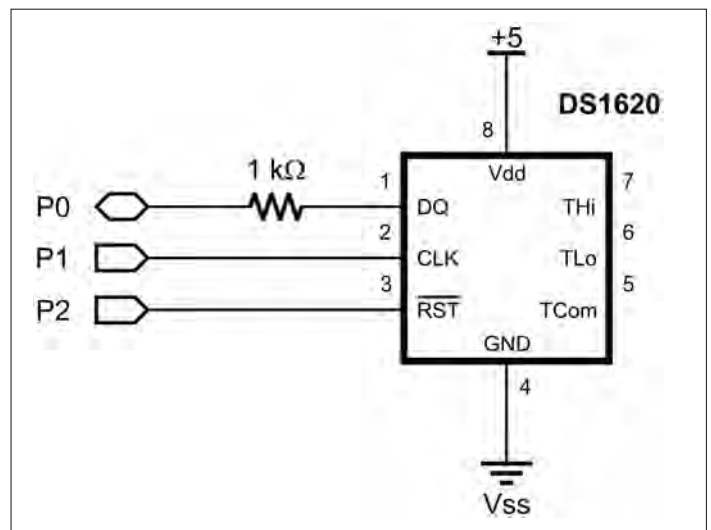
```
Private Sub Timer1_Timer()

  If Len(bs1Buffer) >= 97 Then
    Parse_Debug_Packet
    Update_Display
  End If

End Sub
```

We could, of course, use any event — a button press,

■ FIGURE 2. DS1620 Connections.



for example — but if the BS1 is constantly streaming data, the serial buffer could be overrun. Since a BS1 **DEBUG** takes about 200 milliseconds (97 bytes at 4800 baud), checking our buffer anytime under this window will make sure the program responds quickly to the output from the BS1. Okay, if we have enough bytes to consider, it's time to get down to the nitty-gritty and fish the BS1 variables out of the **DEBUG** stream (*Oi vai, that was corny*).

```
Private Sub Parse_Debug_Packet()

    Dim syncStr As String
    Dim foundSync As Long
    Dim checkLen As Long
    Dim idx As Byte

    syncStr = String$(17, &HF0) & String(1, &H5A)
    foundSync = InStr(1, bs1Buffer, syncStr, vbTextCompare)

    If (foundSync > 0) Then
        checkLen = Len(bs1Buffer) - (foundSync + 18)
        ' do we have the whole packet?
        If (checkLen >= 32) Then
            bs1Buffer = Mid$(bs1Buffer, (foundSync + 18))
            bs1IORegs(0) = Asc(Mid$(bs1Buffer, 18, 1))
            bs1IORegs(1) = Asc(Mid$(bs1Buffer, 17, 1))
            bs1IORegs(2) = Asc(Mid$(bs1Buffer, 7, 1))
            For idx = 0 To 13
                bs1ByteRegs(idx) = Asc(Mid$(bs1Buffer, (19 + idx), 1))
            Next
            For idx = 0 To 6
                bs1WordRegs(idx) = (CInt(bs1ByteRegs(idx * 2 + 1) * 256) _
                    + bs1ByteRegs(idx * 2))
            Next
            bs1Buffer = Mid$(bs1Buffer, 32)
        End If
    End If

End Sub
```

This may look a little tricky at first, but really — it's not that bad. One of the nice things about using the serial port object in VB is that the buffer is treated like a string; this fact lets us use some of the neat string functions of Visual Basic. We see that first with the creation of *syncStr*. On the advice of Parallax's compiler engineer, Jeff, we want to look for at least 17 sync bytes (\$F0) followed by the \$5A packet descriptor. This is pretty simple using VB's **String\$()** function. With that string created, we can use the **InStr()** function to determine if the **DEBUG** sync header exists in the buffer. If not (could have been a Connect packet), we simply exit the subroutine. If the sync header is present, then we can parse out the variables.

Before we attempt to do the parsing, however, we need to ensure that we've got the entire packet. It is possible that the serial port got closed in the middle of the BS1 **DEBUG** output and we don't have the whole thing. It's a simple matter to check — we look at the starting position of the sync string in the buffer, move forward 18 bytes (to account for the sync string), and then check to see if there are at least 32 bytes left in the buffer. If the answer is yes, we move on with the parsing.

We'll start by using the **Mid\$()** function to trim away the leading sync and packet descriptor bytes. After that, it's a

simple matter of pulling the variables from their respective positions in the stream. In this program, we have three arrays: *bs1IORegs()* which holds the DIRS and PINS (one for Outs, one for Ins) values, *bs1ByteRegs()* which holds the values of BS1 variables B0-B13, and *bs1WordRegs()* which is actually assembled from the values of *bs1ByteRegs()*.

Of particular note is the *bs1WordRegs()* which is an array of Longs. In VB, an integer is a 16-bit signed value, so assembling the unsigned word variables from the byte variables requires more bits. Longs use four bytes so that gives us the space to handle any value in a BS1 word variable. As you can see, we have to use the **CLng()** (convert to Long) function to ensure the value is correctly calculated.

Note that when accessing strings in VB, the first byte is in position 1. Knowing this, we can see that the *PINS* inputs are in position 7, the *PINS* outputs are in position 17, the *DIRS* register is in position 18, and, finally, *B0-B13* are located in positions 19-32. These positions correspond with their locations in the PIC RAM space.

Okay, once the current values are parsed out, we trim the packet from the front end of the buffer and move on to other things. See, it's not that bad.

So, what do we do now? Well, while developing the program, I thought it might be useful to create a little utility that displays the BS1 **DEBUG** data. A screen shot of that program is shown in Figure 1. For those of you who have used VB, you know that VB doesn't know how to display binary variables — the solution is a simple custom function that takes a value and converts it to a binary string:

```
Private Function BinStr(value As Long, width As Byte) As String
```

```
    Dim idx As Byte
    Dim testBit As Long
    Dim tmpBin As String

    testBit = 2 ^ width
    value = value Mod testBit
    tmpBin = ""
    For idx = 1 To width
        testBit = testBit \ 2
        If (value >= testBit) Then
            tmpBin = tmpBin & "1"
            value = value - testBit
        Else
            tmpBin = tmpBin & "0"
        End If
    Next
    BinStr = tmpBin
End Function
```

This works similar to the BIN modifiers in the BS2. If, for example, we wanted to display the lowest four bits of a value, we would use the function like this:

```
lblLedStatus.Caption = BinStr(ledStatus, 4)
```

The routine is pretty simple — it calculates the next-highest bit value and truncates any unneeded bits from the input with **Mod** (modulus). Then, it's a simple matter of looping through each bit position to see if it's set. This is done mathematically instead of logically; it's just simpler that way in VB. The result is a binary string representation of our

value. In the full program listing, you'll find a similar function for converting values to fixed-width hexadecimal strings.

You can use the BS1 DEBUG Viewer application with any BS1 program that has at least one **DEBUG** instruction. One of the interesting things you'll see is the manipulation of *W6* by a program that uses **GOSUB** — *W6* is used as the **RETURN** stack. You'll also see that the *PINS* outputs will affect the corresponding *PINS* inputs.

SHOW ME THE TEMPERATURE

As most of you know, I am *freakishly* sensitive to the temperature of my environment, hence, I'm constantly looking at thermometers and adjusting the thermostat. Perhaps I need professional help ... well, until that day, I decided to make it easier to check the temperature where I spend most of my day — in front of my computer.

What I did is take an eight-pin socket and extend the legs with wire and a 1K resistor to match our standard DS1620 circuit, as shown in Figure 2. I popped a DS1620 into the socket and plugged my temperature "spider" into the USB-BS1. Figure 3 shows the contraption plugged into my PC's USB port.

From there, it was a very simple matter to gut and convert the BS1 DEBUG Viewer application to display temperature. Since we've used the DS1620 so many times in the past, I'm not going to go through all the details — I just want to cover shifting data out and in with the BS1.

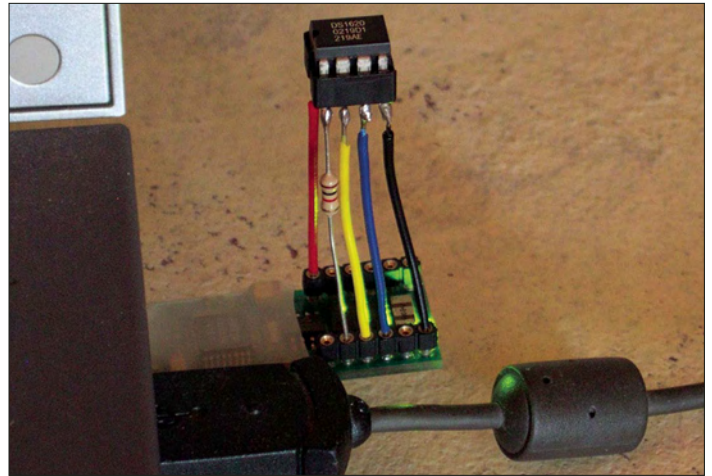
The BS1 does not have the BS2's **SHIFTOUT** and **SHIFIN** instructions, so we're forced to synthesize these in code. It's really pretty simple. One of the things you'll notice about my BS1 programs is that I always start assigning variables at B2 (or *W1*). The reason for this is that I want to leave B0 and B1 (*W0*) free in case I need bit-level access later (*W0* is the only variable that allows bit-level access). That is the case with shifting subroutines; let's have a look.

Here's a subroutine that will shift an eight-bit value to the DS1620, LSB first:

```
Shift_Out:
  DIRS = %00000111
  Clock = IsHigh
  FOR shift = 1 TO 8
    DQ = BIT0
    PULSOUT Clock, 10
    dByte = dByte / 2
  NEXT
  RETURN
```

The key section here is the middle of the **FOR-NEXT** loop. Notice that DQ (the output pin to the DS1620) is set to the value of *BIT0*. This is the LSB of *B0* which, in this program, is aliased as *dByte*. After placing the bit on the DQ line, the clock line is blipped with **PULSOUT**, and then the value of *dByte* is divided by two. Dividing by two is the same as shifting right by one bit, so this process puts the next highest bit into the *BIT0* position.

Coding to shift bits in is similar. In the DS1620, the temperature returned as a nine-bit, two's-complement (if negative) value, with the MSB is used as the sign (0 for positive, 1 for negative).



■ FIGURE 3. DS1620 Spider.

```
Temp_In:
  DIRS = %00000110\
  tempC = 0
  Clock = IsHigh
  FOR shift = 1 TO 9
    tempC = tempC / 2
    Clock = IsLow
    BIT8 = DQ
    Clock = IsHigh
  NEXT
  tempHi = -sign
  RETURN
```

As you can see, things are reversed. The first thing we

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■ **FIGURE 4. BS1 Temperature Watch Program.**

do is shift the result variable (*tempC*) to the right, the clock gets blipped, and then we collect a bit from DQ and put it into the MSB position

(*BIT8*). This seems odd at first, but after you work your way through it makes good sense.

Since we only get nine bits back from the DS1620, but need all 16 bits of a word to be properly configured to designate a negative value, the final line of [working] code handles this neatly for us. And (big bonus here) Visual Basic understands PBASIC negative values. This makes the temperature display program a breeze to code. Here's the working part:

```
Private Sub Timer1_Timer()

    If Len(bs1Buffer) >= 97 Then
        Parse_Debug_Packet
        tempC = CSng(bs1WordRegs(0)) / 2
        tempF = tempC * 9 / 5 + 32
        Update_Display
    End If

End Sub
```

How simple is that? After we get and parse a **DEBUG** packet, the value of *W0* (this is what we use to return the raw value from the DS1620) is converted to floating point with the **CSng()**

function and the rest is automatic. Remember that the DS1620 returns the temperature in units of 0.5 degrees Celsius, so we have to divide by two to get the correct value. Converting to Fahrenheit requires just a bit of high school math. I kept the program very simple — you can see the output in Figure 4.

One last note on using the BS1 — there is no way to get information from our PC application to the BS1 through the programming port. If that limitation is not a barrier, you now have the expertise and the means to use the BS1 for getting information into your PC application.

And, finally, my friends at *Nuts & Volts* have asked me to put additional focus on completed projects. That's okay by me, and I'd really like to do projects that many people will find interesting and useful. I'm currently working on a six-digit, 13-segment display using an exciting new product that Parallax will be announcing shortly. What kind of projects would you like to see? Please email your ideas, and I'll see what I can do about turning them into full-blown projects.

Until next time, Happy St. Patrick's Day and Happy Stamping! **NV**

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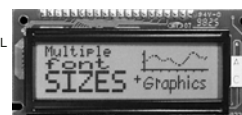
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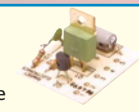
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The Newest And Neatest Goodies

Digital FM Stereo Transmitters

- ✓ Monitors the entire aircraft band without tuning!
- ✓ Passive design, can be used on aircraft, no local oscillator, generates and creates no interference!
- ✓ Great for air shows
- ✓ Patented circuit and design!

For decades we have been known for our novel and creative product designs. Well, check this one out! An aircraft receiver that receives all nearby traffic without any tuning. It gets better... there is no local oscillator so it doesn't produce, and can't produce, any interference associated with all other receivers with an LO. That means you can use it onboard aircraft as a passive device! And what will you hear? The closest and strongest traffic, mainly, the one you're sitting in! How unique is this? We have a patent on it, and that says it all!

This broadband radio monitors transmissions over the entire aircraft band of 118-136 MHz. The way it works is simple. Strongest man wins! The strongest signal within the pass band of the radio will be heard. And unlike the FM capture effect, multiple aircraft signals will be heard simultaneously with the strongest one the loudest! And that means the aircraft closest to you, and the towers closest to you! All without any tuning or looking up frequencies! So, where would this come in handy?

1. At an air show! Just imagine listening to all the traffic as it happens
2. Onboard aircraft to listen to that aircraft and associated control towers
3. Private pilots to monitor ATIS and other field traffic during preflight activities (saves Hobbs time!)
4. Commercial pilots to monitor ATIS and other field traffic as needed at their convenience
5. General aircraft monitoring enthusiasts

Wait, you can't use a radio receiver onboard aircraft because they contain a local oscillator that could generate interfering signals.

We have you covered on that one. The ABM1 has no local oscillator, it doesn't, can't, and won't generate any RF whatsoever! That's why our patent abstract is titled "Aircraft band radio receiver which does not radiate interfering signals". It doesn't get any plainer than that! Available as a through-hole hobby kit or a factory assembled & tested SMT version.

| | | |
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| ABM1 | Passive Air Band Monitor Kit | \$89.95 |
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SPECIFICATIONS

| | |
|-----------------------|---|
| Frequency Range: | 118 MHz to 136 MHz |
| Receiver Type: | Patented Passive Detector |
| IF Frequencies: | None! |
| Receiver Sensitivity: | Less than 2 uV for detectable audio |
| Audio Output: | 700mW, 8-24 ohms |
| Headphone Jack: | 3.5mm stereo phone |
| External Antenna: | Headphone cord coupled |
| Power Requirement: | 9VDC battery |
| Dimensions: | 2.25" x 2.8" PC Board 2.5" x 4.6" x .9" Case |
| Weight: | 4 oz. with battery |

Hand Held Wind Speed Anemometer

- ✓ Displays instantaneous wind speed!
- ✓ Stores & records maximum gusts and averages!
- ✓ Displays temperature and wind chill in °F or °C!
- ✓ Beaufort wind scale bargraph!

We have all seen them on TV... the professional weather talent (now known as meteorologists!) standing in the middle of the hurricane report holding up their wind meter clocking the fastest wind gusts. Usually that's just before they get blown to the ground along with their producer and camera crew! Well now you can have the same professional wind speed meter on a hobbyist budget! Besides displaying the realtime instantaneous wind speed in your choice of MPH, KM/H, M/S, or Knots, it also stores and records the maximum gust AND average since it was powered up! In addition, realtime wind speed is also displayed on a Beaufort wind scale ranging between 0 and 12. Housed in a rugged, weather resistant case and includes a neck strap for easy carrying. Runs on a single lithium button cell that is included. Factory assembled, tested, and ready to go!

| | | |
|--------|--------------------------------|---------|
| EA3010 | Handheld Wind Speed Anemometer | \$49.95 |
|--------|--------------------------------|---------|

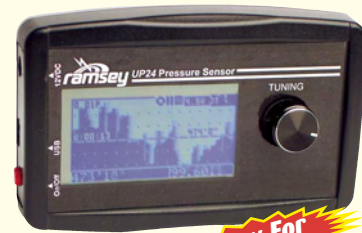


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- ✓ Multiple built-in alarms



New For 2006

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We really did it this time! The UP24 is one of our most advanced kits to date, and an absolute MUST for anyone serious about the environment around us! But the applications only begin there.

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Unlike your normal run-of-the-mill barometer, air pressure is sensed in Pa's or kPa's. What are those you may ask? Pascals or KiloPascals. However, don't be afraid, for your convenience, and to fit any application you may have, it is also displayed in millibars, bars, PSI, atmospheres, millimeters of mercury, inches of mercury, and feet of water! Take your pick! The range of the UP24 is 15kPa to 155kPa.

We've talked about air pressure, now let's talk about elevation! The incredibly precise 24 bit A/D converter in the UP24 looks at the air pressure and converts it to elevation above sea level. In both graph and text, the elevation is displayed to a resolution of 1/3"! Yes, I said 1/3 of an inch! The applications for the super accurate elevation meter are endless. From watching and recording elevations during hiking trips to measuring and recording the wave heights on boats! Let your imagination take over from there!

What if you're in the field and you want to save data captured in your UP24? The built-in FLASH storage provides 13,824 samples of storage. Then you can transfer your data to your PC with a standard USB interface.

While the UP24 is small enough to be kept in your coat pocket it boasts a large 2.78" x 1.53" 128x64 pixel LCD display screen making viewing easy. Display modes include both realtime pressure and elevation graphs as well as pressure and elevation statistics. There are 12 user selectable sample rates from 1/10th of a second all the way up to every 15 minutes.

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WHAT'S UP:

This month's Q&A — some new and unusual questions and answers!

■ WITH TJ BYERS

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, comments, or suggestions.

You can reach me at: TJBYERS@aol.com



Why loudspeakers are different.



Phone busy alert.



Two optical switching circuits.



T-Bird tail lights.

SO MANY TO CHOOSE FROM

Q I have noticed a large variety of “impedance” ratings for speakers; such as four ohms, eight ohms, 16 ohms, and others. Why so many? Is it just to make the design of the power amplifier easier by matching the output impedance?

— Jeff Dunker

A Well, that's part of the answer — but it's not the whole story. Let's begin with the physical construction of a loudspeaker, as shown in Figure 1.

Basically, a loudspeaker consists of a voice coil (electromagnet) suspended in a magnetic field. When a current is run through the coil, it creates a magnetic field that forces the coil inside or outside the magnetic field — according to the strength of the cur-

rent and its polarity. The stronger the electromagnetic field, the farther the displacement (throw) of the voice coil with respect to the permanent magnet.

If an AC voltage is applied across the voice coil, it will move in and out as the field changes polarity. The voice coil is glued to a paper or plastic cone that moves in step with the voice coil. This movement translates the electron flow into air movement — a.k.a., sound.

Early on in the development of audio amplifiers, many methods were used to produce this movement. The most feasible was and is the voice-coil loudspeaker described above. The critical element of this design is the voice coil itself. It is nothing more than many turns of copper wire — wire that has resistance that's measured by the foot.

For example, a typical eight-ohm, four-layer woofer voice coil contains about 120 feet of number 28 solid copper wire. That's a lot of wire to shove into the small gap between the north and south poles of the permanent magnet. Consequently, it's physically more practical to use a smaller wire with more resistance than it is to use larger wire, which is harder to work with when forming a rigid voice coil destined for a small space.

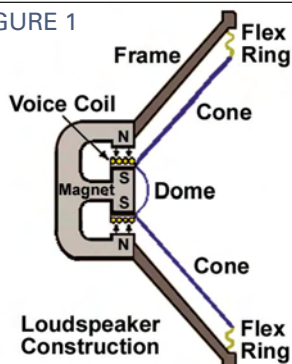
But here comes a trade-off. Current times voltage makes watts. So voice coils with more resistance require more voltage to produce the same wattage. In the days of vacuum tubes, this wasn't a problem. They required hun-

dred of volts on the plate and an output transformer in their design, so loudspeakers of that era were typically 16 to 32 ohms because the value best fit the tube to transformer coupling — and the materials and manufacturing methods of the time.

With the advent of semiconductors, voltages decreased and currents increased. That coupled with the discovery of rare-earth permanent magnets with stronger magnetic fields (versus Alnico) made it realistic to use lower resistance coils. For example, the car stereo market uses almost nothing but four-ohm speakers due to voltage limitations available in cars (specifically 12 volts). More power can be driven into a four-ohm speaker than an eight-ohm speaker (assuming the same driving signal).

Are four-ohm speakers better than eight-ohm speakers? Absolutely not! The ohm rating of a speaker has nothing to do with the quality of the speaker. But it has a lot to do with the way you wire an array of speakers together. Is an eight-ohm speaker really eight ohms? Not likely. Due to the highly complicated nature of a loudspeaker, its impedance is not a simple number, but an AC reactive value that changes with frequency and loading that can vary between six and 20 ohms. But that's a story for another day. For now, when a speaker is said to be four or eight ohms, this is understood to be its nominal impedance.

■ FIGURE 1



I'M BUSY!

Q I have one land line phone service to my house that I share with the upstairs and my computer room in the basement. I have it connected so that if I want to go on to the Internet, I flip a switch that disconnects all the phones in the house and connects the line to my computer only. If the wife goes to use the phone and hears no dial tone, she knows I'm online. Works great — except for one problem — I can't tell if she's on the phone before I flip the switch (short of listening in on her conversation!). Is there a circuit (possibly LED) that will light when she is using the phone?

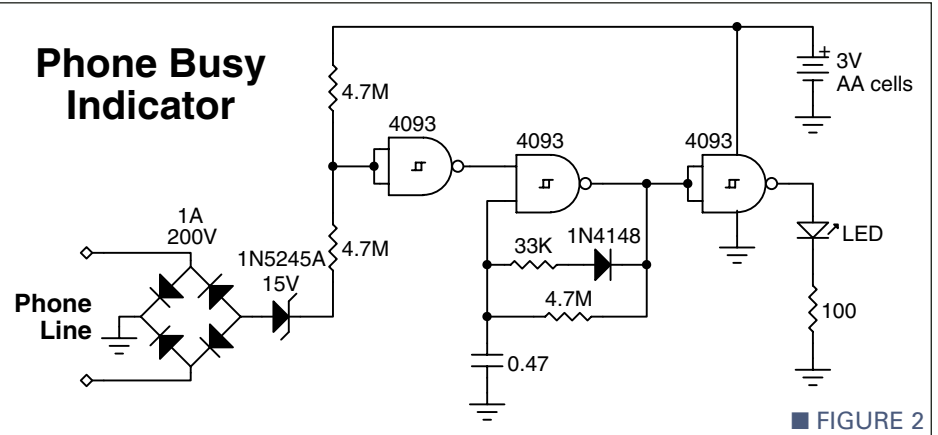
— Ted Petra

A Here's a very reliable circuit — Figure 2 — that has several unique features. Specifically, it isn't polarity sensitive to the phone line (the red and green wires are interchangeable) and it will run for about a year on two AA cells. This is thanks in part to the low 0.25 μ A standby current of the 4093 IC, and the fact that the LED flashes for a short 16 milliseconds once every second.

All stages are Schmitt NAND gates. The first gate functions as a voltage comparator, the output of which goes high when the telephone line voltage drops below 15 volts. This triggers the second gate, which is configured as a pulse generator. Ordinarily, this design produces a symmetrical square wave with a 50% duty cycle. By adding a 1N4148 steering diode and a 33K resistor in the discharge path, the duty cycle is lowered to 16% for an average current of less than 100 μ A when the phone is in use (don't email me with your math without first looking at the 4093 data sheet!). The final gate buffers the pulse generator and drives the LED.

BOWL-A-RAMA CIRCA 1909

Q I am an electronics vocational teacher at the Orleans BOCES (Vocational). My students are working on a new project and we've hit a snag. We



■ FIGURE 2

are making a Skee-ball game and I need to trigger the input to our Automation Direct PLC with a signal from a sensor when the ball drops into the scoring hole. I am trying to use a 2N3904 transistor and trigger it with a photoresistor. I think our trouble is that the ball is 3" across and we're using LEDs to shine on a CdS photocell. It works fine if the light is a small flashlight, but not the blue LEDs we have tried. We really want to use LEDs for reliability. The PLC operates at 24 VDC.

— Bill Leggett

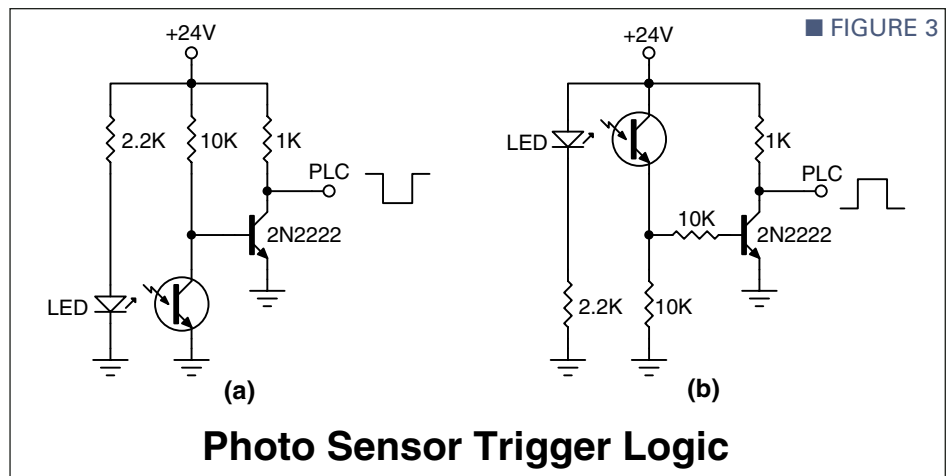
A Silly to say — I didn't know what Skee-ball was — even though I used to hang out in arcades in my teens (circa 1960). I guess Skee-ball had fallen out of favor by that time. So I did some research on this 1909 invention and discovered your problem in recreating it. The original design used crosshair switches and latching relays (a very clever design/game for its time!), not photoresistors.

A CdS photoresistive cell is

the wrong choice. Their primary application (today) is in night/day applications where they turn on and off street lights. To accomplish this, they have a very large surface area — an area that a single LED is hard pressed to cover with any effect. This is why the flashlight works (full sun) and the LED doesn't (moonlight).

The answer is to replace the photoresistor with a phototransistor (www.allelectronics.com CAT# PTR-1). It's about 1/4" in diameter and is easily recessed into a hole drilled into the wood/plastic wall of your Skee-ball cylinder. Use a high-intensity red LED (All Electronics CAT# LED-94) on the opposite side for your light source; red because the phototransistor is more sensitive to red wavelengths than it is to blue. For the circuit itself, you need nothing more than the phototransistor and an NPN output transistor as shown in Figure 3.

When the light strikes the photo-sensor — version (a) — the PLC output goes high. When the beam is interrupt-



■ FIGURE 3

Photo Sensor Trigger Logic



ed by a Skee-ball, the output goes low for as long as the ball falls through the slot, then returns to high. If your logic wants the sensor to be low then go high, use the (b) version of Figure 3. I've never tested these resistor values with the All Electronics parts recommended, so you may have to tweak the 10K resistors up (no higher than 100K) to get a positive response. If a brighter light source is needed, the 2.2K resistor can be reduced down to 1K with no ill effects.

THE IN-N-OUT SENSOR

Q I have a motion light for the bathroom that is set for two minutes. I would like to replace it with an infrared sensor that would come on when I walk in and off when I go out.

— Clarence Hawkins

A An IR heat sensor won't work as you plan because it will give false readings from a lingering shower, space heater, and other heat sources that remain after you've left the bathroom. How about an ingress/egress detector that would monitor your direction into or out of the room and control the light accordingly? All it takes is a pair of photosensors steering

a logic circuit, as shown in Figure 4.

The circuit works by determining which photosensor is activated first. Let's say the light source to Q1 is interrupted first. This causes the monostable timer (4001 gates) to start and lock the states of Q1 (HIGH) and Q2 (LOW) into the 4027 flip-flop. This causes the Q output of the flip-flop to go high and pull in the relay. It also locks out the sensors for one minute so that further movement will be ignored. When you exit, Q2 is blocked and the Q output goes low, causing the relay to drop out.

Placement of the sensors is critical. Obviously, they have to be placed horizontally, one in front of the other. And they have to be spaced far enough apart so that both aren't darkened at the same time, yet close enough to be illuminated from a convenient light source — which can include IR LEDs, a night light, or ambient room light. The sensitivity pots adjust the trip point of the sensors. Cadmium sulfide photocells can be used in place of phototransistors Q1 and Q2.

COMPUTER PROBLEM

Q I was trying to Network Neighborhood my two computers to share my Panasonic printer from one computer

to the other. I started with My Computer and went to — Printers, Panasonic Printer, Properties, and to Details. Where it asked "To Print To The Following Port, I mistakenly entered Panasonic instead of LPT1. Now when I try to click onto the Panasonic printer I get an Illegal Operation — with an explanation SPOOL 32 caused a stack fault in module KERNEL 3.2.DLL at 016f:bff7a2a1.

I tried to delete the Panasonic icon, but it won't let me. To get out of this situation, I had to End Printers Task and shut down the computer. When I restart the computer everything works okay as long as I stay away from the Panasonic icon. Even highlighting the icon puts the system into an illegal program situation. Is there a way to rectify this problem?

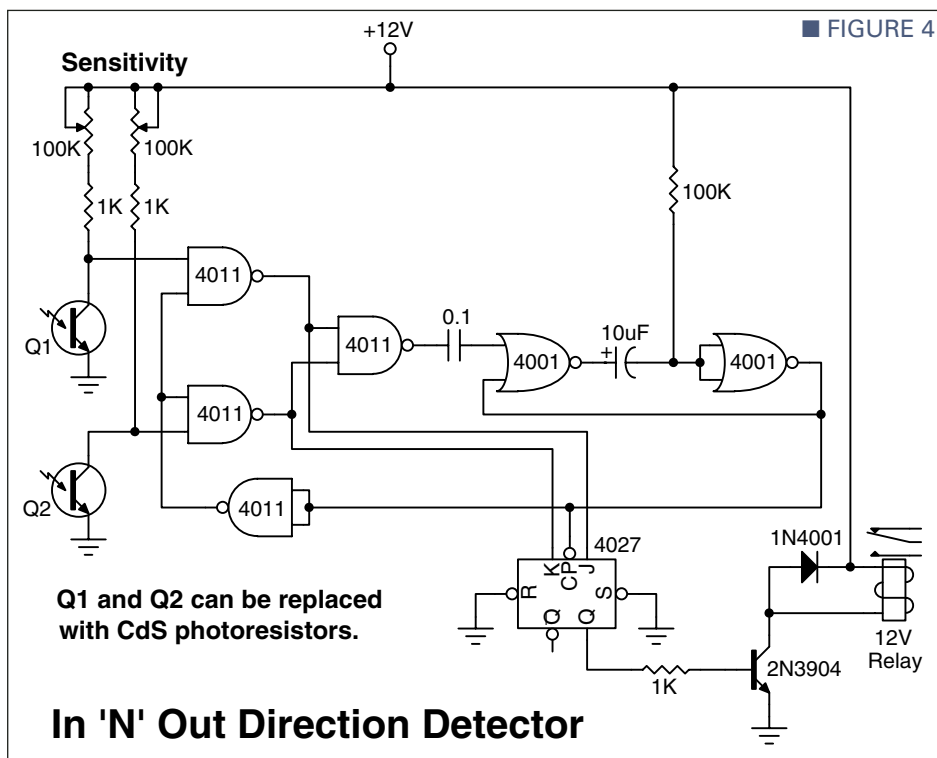
— Scott Jones

A Normally I don't answer questions that deal with specific operating system software errors, but this is one I ran across myself recently and can answer without reserve. The problem is in the Windows XP Registry. You have cross-linked the two devices (port and printer) and XP is confused, which is why you are getting the error message. You need a good Registry software program to set things straight.

I personally use Registry Mechanic from PC Tools (www.pctools.com), which sells for \$29.99, but a search of the web will turn up both freeware and shareware for less — most of which I haven't tested. I suggest that all Windows XP users do an occasional scan of their Registry — and each time you make a change to your system. You never know what secrets are lurking in a new application.

T-BIRD TAIL LIGHTS

Q A friend who creates miniature dioramas of vintage automobiles recently asked me if I had ever seen a circuit that would simulate the turn signals for a 1967 Ford Thunderbird. When triggered, the first LED would light, then a second LED, and then a third. At this point, the display goes dark and the cycle repeats. He wants to activate



either the left- or right-turn signal from outside the diorama using a momentary contact switch. Do you have any suggestions?

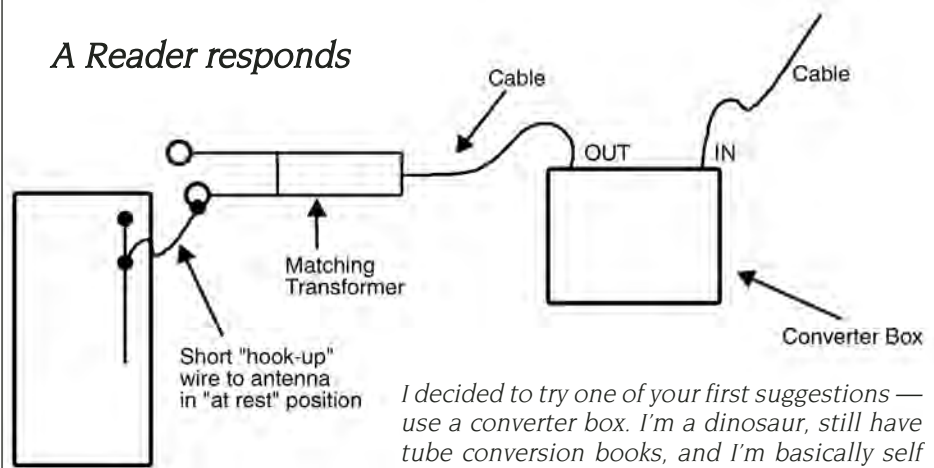
— Jon Westcott

A In the original Ford design, the direction indicator used a series of cams on a single shaft that would close then open three micro switches in sequence when the shaft was rotated. Essentially, a mechanical timer that turned on when the turn switch was activated. Of course, that was 40 years ago, before they began putting micro-processors in cars.

Today, the solution is a serial in/parallel out shift register — like the 4015 circuit shown in Figure 5. A shift register is a series of flip-flops that moves (“shifts”) a train of pulses from the input to the output. If you monitor the pulse train at each stage, you can watch it ripple from the beginning to the end. This is what a serial in/parallel out shift register does.

To make a T-Bird signal, the flip-flops are first cleared to zero. The data input (pin D) is then taken high and

A Reader responds



I decided to try one of your first suggestions — use a converter box. I'm a dinosaur, still have tube conversion books, and I'm basically self taught. But like all electronic buffs, I have boxes of old "stuff." Among the junk I found an old cable converter box — and it works perfectly. I set the TV to channel 3 and tune from the converter.

— Richard

transferred to the first flip-flop on the rising edge of the clock signal (generated by the 4011 CMOS oscillator). This sets the Q1 output high. Again, the data input is set high and clocked into the first flip-flop. This causes the data bit in the first flip-flop to advance and be locked in the second flip-flop. We now have outputs Q1 and Q2

high and output Q3 low — that is until the next clock pulse which moves the bits one more step down the line and lights all three LEDs.

Now comes the fourth clock pulse. At this point, we enter another one (high) into the register, which causes Q4 to go high. It just so happens that when the reset input (pin R) goes high — notice it's tied to Q4 — it clears all the outputs to zero. Lights out. The next clock pulse then inputs a one bit into the first flip-flop, and it begins all over again.

To start the sequence, you need to press and hold down the left or right push-button — depending on which direction you want to go. Pressing both at the same time will give you the brake light effect of the T-Bird and later the Mercury Cougar.

KEEP THAT JUNK BOX FULL

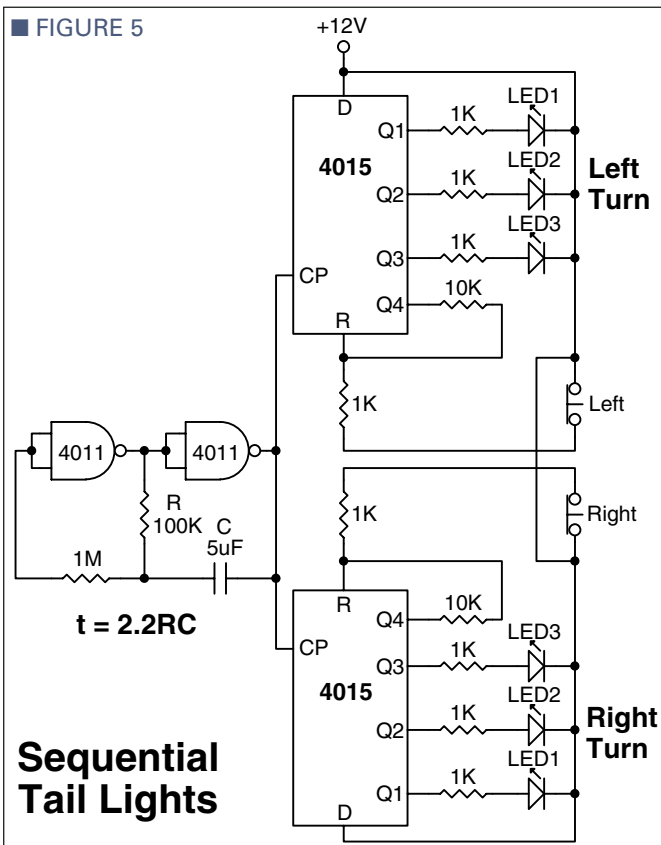
Q I have a small TV that fits well at my desk/work station. It's an older model Panasonic TR-1010P with a telescoping antenna and no external antenna connection. Is there a modification that will allow me to connect this TV to cable?

— Richard Gravina
Decatur, GA

A A few fixes pop to mind. But the fact that this is a pocket TV with a 1.5" screen limits the choices. As in, it rules out popping the cover and adding a jack. The point of entry has to be through the whip antenna.

If your desk is metallic, or has a metallic apron or legs, first tie the braid of the coax from the cable to a metallic part of the desk. If it's all wood, place a piece of aluminum foil under the TV set (making a ground plane) and tie that to the braid. Sec-

■ FIGURE 5



Sequential Tail Lights



ond, collapse the antenna to minimum length and rested position. Finally, connect the center conductor of the cable to the rod antenna through a 100 pF or similar low-value capacitor.

If the signal strength of the cable is too strong, the TV's AGC (automatic gain control) won't be able to cope and some channels will distort. If this happens, place a cable attenuator (20 dB) in line with the cable before the capacitor take off.

STAMP COLLECTING SECRETS

Q I'm trying to make a UV watermark detector (using UV LEDs) to help find watermarks on stamps. I've tried to use the basic LED flashlight approach to no avail.

— Phil Perez
USMC, Ret.

A Watermarks are placed on business letterhead, bank notes, currency, and postage stamps. Originally, watermarks meant the areas of a document where the paper was pressed thinner than the whole — usually in the form of an image or initials. In recent years, watermarks have given way to fluorescent paper/inks and phosphor tagging.

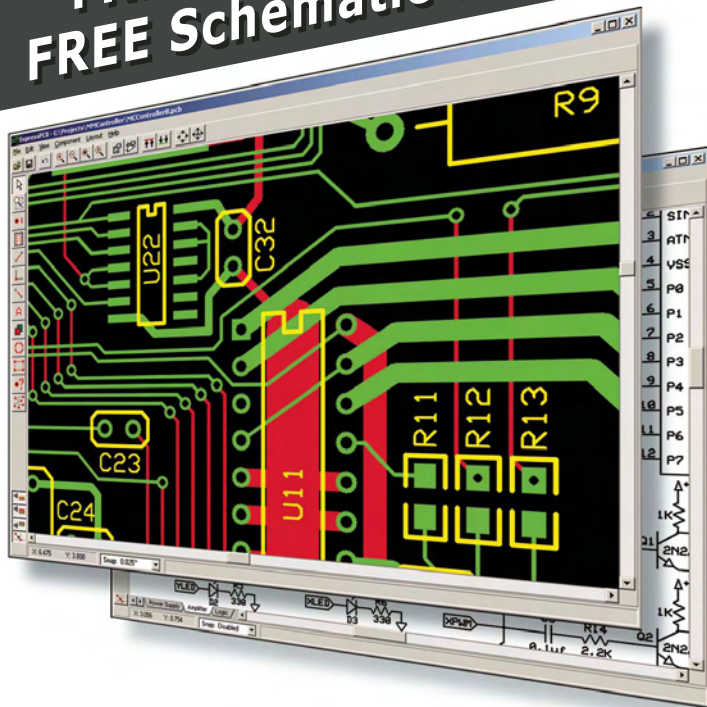
Fluorescence — Stamp paper or inks containing fluorescent dyes that glow when exposed to long-wave ultraviolet light with a peak wavelength of 365 nm. There is no afterglow. Fluorescent papers usually glow a bluish-white; stamp inks containing fluorescent dyes can glow in a variety of colors.

Phosphor Tagging — A clear phosphor colloidal solution (tagging ink) applied over a stamp, to its paper, or mixed with the ink. Tagging glows when exposed to short-wave ultraviolet light that peaks at 254 nm, and has a brief afterglow that is used by automatic canceling machines to find, face, and cancel an envelope's stamp. Reddish tagging was only used for air mail stamps from 1963 to 1978. Beginning 1978, bluish-green tagging was used for all subsequent air mail stamps.

Now for the bad news. There are very few ultraviolet LEDs on the market that emit at 380 nm, fewer at 365 nm — and none that emit below 365 nm, certainly not at 254 nm. Which leaves you with fluorescent tubes. Fortunately, blacklight tubes — as they are called — are readily available at these wavelengths. And they don't require a special light fixture. A battery-operated, fluorescent lamp often sold for emergency lights in auto glove compartments is perfect. You can find the blacklight tubes at gem shops or stamp supply stores. **NV**

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| Cherry | Seasonic |
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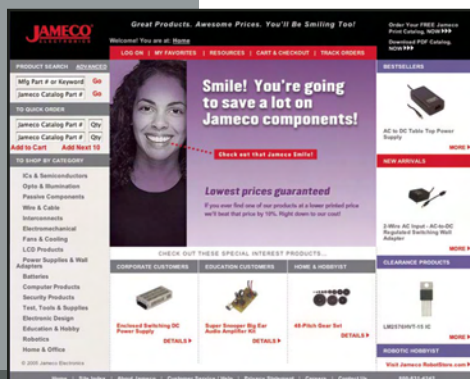
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flapping my jaws so we can get to work. Let's begin by bringing up the MC68HC908MR16's RS-232 serial port.

CODING AND ACTIVATING THE MC68HC908MR16 RS-232 PORT

Before we begin, I would like to

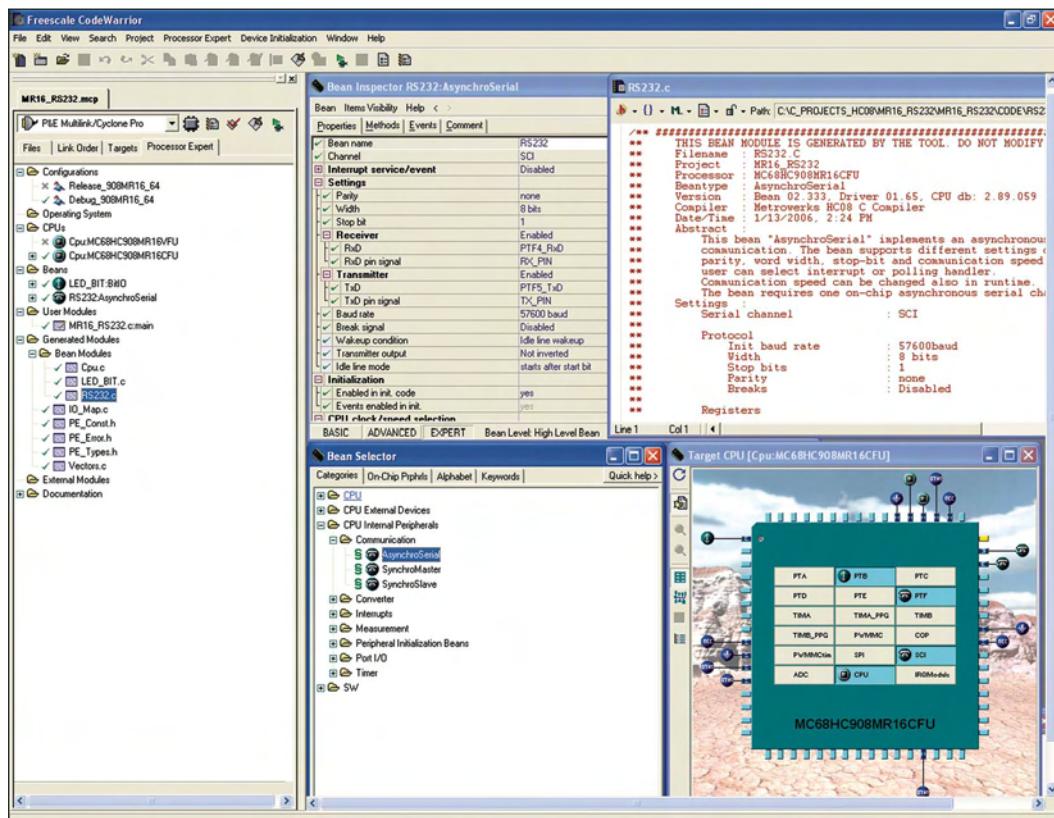
point out that when you see numbers like "0x12345" in this text, the 0x denotes hexadecimal representation. A 0b preceding a string of 1s (ones) and 0s (zeros) denotes a binary representation of the number in the spotlight. An "x" inside a binary or hex number string represents a "don't care." As you'll see, I will use an "x" as a place holder when I'm highlighting certain bits in a binary number or set of hex characters.

You'll also want to go ahead and download all of the MC68HC908MR16 project files, as I'll be referencing them as we go along. You can get them from the *Nuts & Volts* website (www.nutsvolts.com) or from the EDTP Electronics website (www.edtp.com).

■ **PHOTO 1.** The Target CPU window is very interesting. I recommend that you click around on its contents to see where you are taken. The Bean Drill consists of choosing a Bean using the Bean Selector, adding the chosen Bean to the project, and configuring the Bean with the Bean Inspector.

FOR YOUR INFO

Listings 1-4 referenced in this article are available on the *Nuts & Volts* website. Go to www.nutsvolts.com



Obtaining an MC68HC908MR16 datasheet from the Freescale website would be a good idea, as well. Okay, now that you've been given the keys and shown the secret codes, let's go get 'em.

We'll build our RS-232 serial port code on the foundation we previously laid for the LED blinker code. As you can see in the Photo 1 screen shot, I've selected the AsynchroSerial Bean from within the Bean Selector window and double-clicked on it to add it to our new C project (MR16_ADC), along with the BitIO Bean we added previously. I then proceeded to configure the AsynchroSerial Bean, which I renamed to RS-232, using the Bean Inspector.

The result of my selecting and configuring the AsynchroSerial Bean and initiating a compile was the creation of a file called RS232.c, which holds all of the C and assembler routines necessary to send and receive characters via the MC68HC908MR16's SCI (Serial Communications Interface). Recall that the same file creation process occurred when we planted the LED_BIT I/O Bean in last month's installment of this column and spawned the LED_BIT.c file.

If you take the time to explore the Bean Inspector's Methods and Events areas, you'll find that many of the advanced RS-232 functions are unavailable. I figure that's because we're using a "FREE" C compiler and you get what you pay for. In any case, all we want to do is send and receive characters via the MC68HC908MR16's serial port and there are enough options we can choose from in the Bean Inspector Methods area to make that happen.

Okay, so now — thanks to the AsynchroSerial Bean — we have some workable RS-232 send/receive code, in addition to our LED blinker I/O code. Adding the RS-232 Bean also posted some changes in the MC68HC908MR16 startup files. Let's examine the low-level initialization code in Listing 1.

At first glance, the statement `setReg8Bits(PTB, 0x04);` (which you and I didn't write) is obviously a function or macro that is most likely setting some bits in an eight-bit register. However, the question may arise as to what do the arguments of this statement represent. An intuitive

guess would be that the bit 2 of I/O Port B is being set (0b00000100). In this case, my guess is correct and as Spock would say, "Random chance seems to have operated in our favor."

To be sure of what the statement's intentions are, all we have to do is place the cursor on the statement in question and right-click. You will be prompted to be taken to the coded definition of the statement which, in this case, is a macro. The definition of `setReg8Bits(PTB, 0x04);` is contained within the `PE_Types.h` file and looks like this:

```
#define setReg8Bits(RegName, SetMask) (RegName |= (byte)(SetMask))
```

Once armed with the supporting macro code, translating `setReg8Bits(PTB, 0x04);` is easy. The PTB (Port B) data latch (RegName) is being "OR"ed with the mask value SetMask (0x04), which sets bit 2 of Port B. The next statement, `setReg8Bits(DDRB, 0x04);` places bit 2 of Port B into output mode by setting bit 2 of the Port B Data Direction Register.

A look at Schematic 1 tells you that the two lines of C source we've just digested are working on the LED, which is attached to bit 2 of Port B. While your eyes are on the schematic, note that the RS-232 port pins are located in Port F territory. Fire up your copy of CodeWarrior Development Studio for HC08 v5.0, pull up the Listing 1 C source (the `Cpu.c` file from the project MR16_RS232) and right-click on the `clrSetReg8Bits(DDRF, 0x10, 0x20);` statement. A window containing the `PE_Types.h` file contents will appear. The breakdown of the code behind the `clrSetReg8Bits(DDRF, 0x10, 0x20);` statement will look like this:

```
#define clrSetReg8Bits(RegName, ClrMask, SetMask)
(RegName = (RegName & ~(byte)(ClrMask))) | (byte)(SetMask)
```

The first argument, `ClrMask` (0x10), specifies which `RegName` bit to clear, while the second argument, `SetMask` (0x20), sets the bit set fourth in the mask, which is bit 5, in this instance. The inclusion of `DDRF` in the macro as `RegName` implies that we are working on the Data Direction Register of Port F. Thus, we are clear-

ing bit 4 of Port F's Data Direction Register providing an input I/O pin for our SCI receive pin.

Conversely, we are setting bit 5 of Port F's Data Direction Register to provide an output I/O function for our SCI transmit pin.

A right mouse click on the next statement, `RS232_Init();`, tells us that the C statement represents a function, which is found in the `RS232.c` file we generated when we activated and compiled our RS232 Bean. Once you navigate to the `RS232.c` file, you'll find that the

`RS232_Init` function simply sets the desired baud rate (we defined the baud rate in the Bean Inspector) and activates the SCI asynchronous transmitter and receiver.

We're done with the foundation of our RS-232 serial port code. What I hope that you have come away with is that you can right-click on functions, macros, declarations, and variable definitions in the project's C source and be taken to the location of a lower level of source code, which will, in most cases, yield a pretty good explanation of the object you right clicked on.

The code snippet from `MR16_RS232.c` shown in Listing 2 applies the RS-232 routines provided by the AsynchroSerial Bean (the RS232 Bean in our program) and echoes any incoming character. I modified our initial LED blinker program for use in the RS-232 echo code. Every pass through the endless loop alternately illuminates and extinguishes the LED. When you're

not thumping on the keyboard to send a character, the blinking LED gives some indication that the program is actually running.

Now that we have a primitive communications portal by way of the MC68HC908MR16's SCI, let's press forward and cook up an analog-to-digital converter Bean.

Looking at the MC68HC908MR16 datasheet, I found that the MC68HC908MR16 houses a 10-channel analog-to-digital converter module with 10 bits of resolution (0x3FF or 0b111111111 full scale). In a nutshell, the MC68HC908MR16 employs an analog multiplexer to select one of 10 analog input channels that feed a successive approximation-based analog-to-digital converter subsystem, which signals the end of an analog-to-digital conversion by raising a flag or generating an interrupt request. The 10-

bit analog-to-digital conversion result is placed in a pair of special-purpose MC68HC908MR16 data registers, ADRH and ARDL. For now, let's put the MC68HC908MR16 datasheet aside and see what the ADC Bean can do for us.

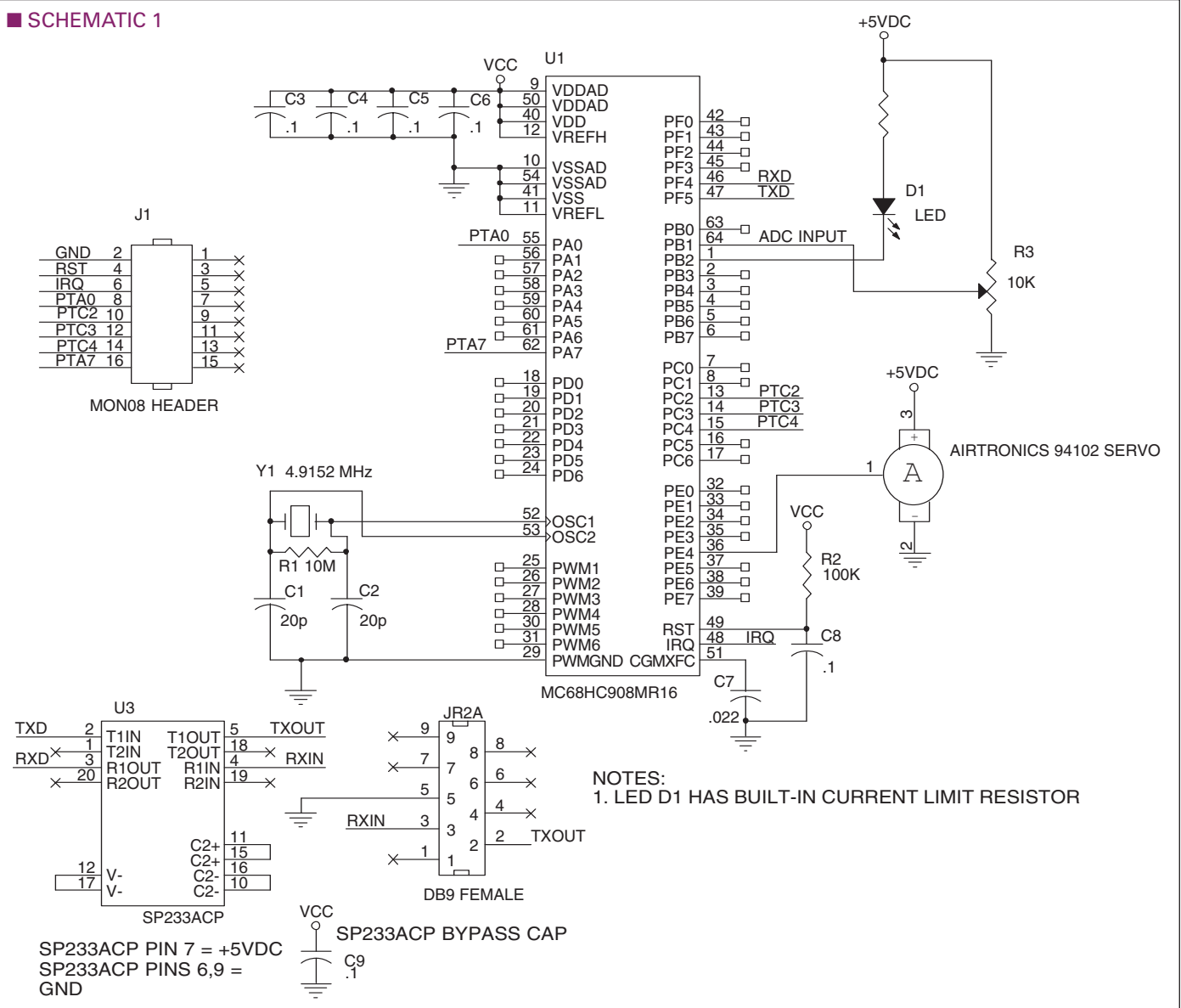
The BEAN configuration process for the ADC BEAN is identical to that of the RS-232 and LED_BIT Beans we configured previously. I accessed the Bean Selector window and double-clicked the ADC Bean to insert it into the new ADC project, which is called MR16_ADC. I noticed that the analog input was assigned to the I/O pin that I was using for the LED. I still want to blink the LED as a run indicator and I don't want to change or throw away the LED code I've already written. So,

I deleted the newly inserted ADC Bean and moved to the Port I/O folder in the Bean Selector window.

Once there, I double-clicked on the BitIO Bean and inserted it into my new MR16_ADC project. Once I saw that the LED had once again assumed my desired position on Port B, I configured the LED_BIT Bean to match the configuration I laid out in the previous RS-232 application we just discussed. I then reinserted the ADC Bean, saw that it was assigned to the next available Port B I/O pin, named it ANALOG, and started the Bean configuration process.

The Bean Inspector wouldn't let me enter anything that would jeopardize the functionality of the MC68HC908MR16 analog-to-digital

■ SCHEMATIC 1



converter. Although there were multiple choices for analog-to-digital converter resolution offered, all of them were disabled with the exception of one. I was forced to choose 10 bits of analog-to-digital converter resolution and I was offered only two choices for conversion time, which were 18.446 μ S and 27.669 μ S. I chose the 27.669 μ S conversion time as its error percentage was specified at 0.000979% versus 2.479% for the 18.446 μ S conversion time.

Within the Methods area of the ADC Bean, I decided to allow the full use of the 10 bits of resolution and nixed any code generation that truncated the analog-to-digital converter's output to eight bits. After compiling the MR16_ADC project for the first time to establish the project's supporting file system and the Bean code for the ANALOG.c file, I copied the MR16_RS232 project's LED blinker code — the endless loop structure — and related includes and variable definitions into the ADC project's MR16_ADC.c application file.

As we discovered earlier, I again had to change the PLL value from 0x1E to 0x66 in the MR16_ADC project's Cpu.c file so that the PLL could lock and provide an accurate clock signal. At this point, I should have a simple LED blinker. Just to check things out, I compiled the project again and loaded it into the MC68HC908MR16. The LED blinked as designed. Things are good.

From experience, we know that the Processor Expert has generated all of the necessary analog-to-digital converter initialization files, which it placed in a file named after the ADC Bean (ANALOG.c). Before we start to add any analog-to-digital converter functions and macros to our project, let's examine the initialization actions that were taken against the analog-to-digital converter configuration registers.

Access the package of MC68HC908MR16 projects you've downloaded from the *Nuts & Volts* or EDTP websites and pull up your copy of ANALOG.c from within the MR16_ANALOG project. ADCLK is the first analog-to-digital converter register that is altered in the analog-to-digital converter initialization

function ANALOG_Init. The macro setReg8 is used to load the ADCLK register with 0x64. The MC68HC908MR16 datasheet tells us that the three most significant bits of the most significant nibble (0b011x) determines the ADC Clock Divide Ratio, which in our case divides the ADC clock by eight. The least significant bit of the most significant nibble (0bxxx0) has a value of zero, which tells us that the analog-to-digital converter is getting its clock from the external clock (CGMXCLK).

Recall that the frequency of CGMXCLK is equal to the frequency of the crystal, which is, for us, 4.9152 MHz. The MC68HC908MR16 datasheet goes on to say that the analog-to-digital converter internal clock must lie between 500 kHz and 1.048 MHz. This internal ADC clock frequency range is called f_{ADIC} . We know that our analog-to-digital converter clock divisor is 8 and our CGMXCLK is 4.9152 MHz. We can calculate our f_{ADIC} as follows:

$$f_{\text{ADIC}} = \text{CGMXCLK} / \text{ADC Clock Divide Ratio} = 4.9152\text{MHz} / 8 = 614.4\text{kHz}$$

Now that we've calculated f_{ADIC} , which is also our ADC frequency, and found it to be within specifications; we can apply some simple math and justify that conversion time figure of 27.669 μ S that the Bean Inspector forced me to choose. Analog-to-digital converter conversion time is defined as follows:

$$\text{Conversion Time} = 16 \text{ to } 17 \text{ ADC Cycles} / \text{ADC Frequency}$$

I'll save us some time and tell you that the Bean Inspector does not use 16 cycles to compute the analog-to-digital converter conversion time. So, substituting the known values we've previously dug up and using 17 ADC cycles:

$$\text{Conversion Time} = 17 / 614.4\text{kHz} = 27.669\mu\text{S}$$

Okay, another mystery solved. Now, let's finish up deciphering the ADCLK value. I specified right justified analog-to-digital converter results in the ANALOG Bean configuration. That is reflected by the two most significant bits of the least significant nibble of the ADCLK value (0bxxxx01xx). Bits 0 and 1 of the ADCLK register are always zero.

The ADSCR (ADC Status and Control Register) is the next register acted upon by the ANALOG_Init function. Again, a setReg8 macro loads the ADSCR register. This time the value loaded is 0x1F, which powers off the analog-to-digital converter module. Hopefully, we'll see some code later that enables the analog-to-digital converter and looks for input from our designated analog input pin. With that, let's put some analog-to-digital converter code together. Listing 3 is a code snippet that is taken from the MR16_ADC.c file. Let's talk about it from top to bottom.

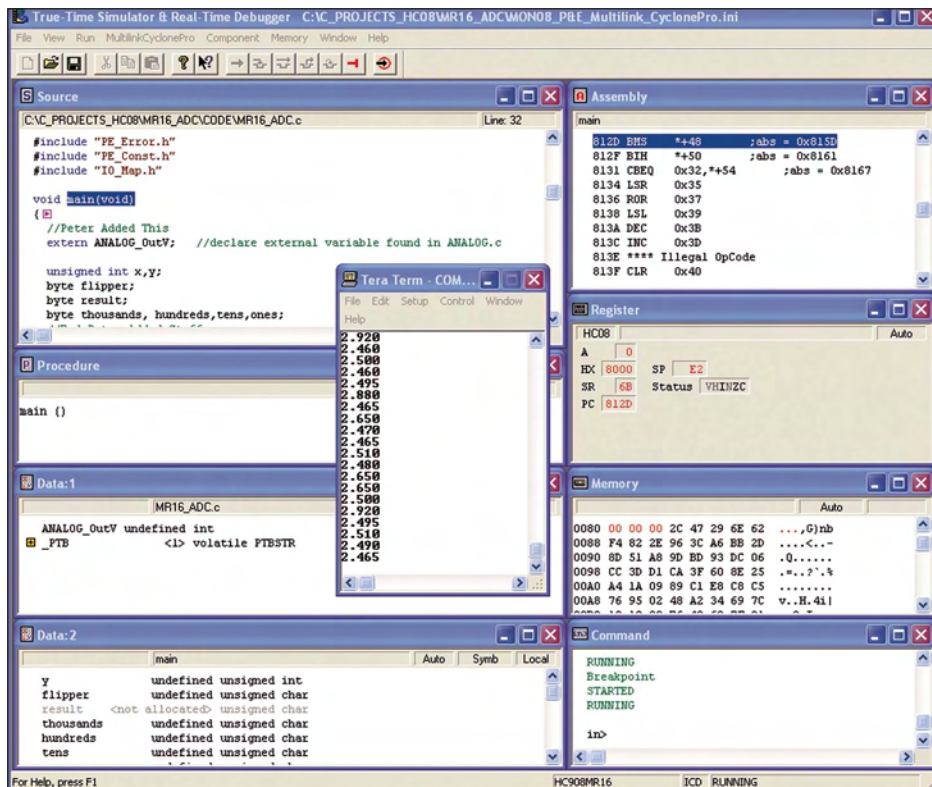
The variable ANALOG_OutV is defined in the ANALOG.c file. To use it here, we must declare it as an external variable. The rest of the variable declarations aren't new. However, I did throw out the "a" and substituted "result" to make things a bit more readable in the source code. The variable declarations are followed by a call to initialize the

MC68HC908MR16 and the peripherals within it we have chosen to use.

The ball starts to roll when we initiate the analog-to-digital conversion using the ADC Bean's ANALOG_Measure function. I have chosen to only take and process one ADC value at a time. The CodeWarrior

Development Studio for HC08 v5.0 C compiler does not include printf functionality automatically in the libraries. So, instead of implementing the printf workarounds presented in the help text, I resorted to caveman tactics to convert the hexadecimal analog voltage readings into something a human can read.

In true caveman style, I allocated four bytes (ones, tens, hundreds, thousands) to represent a number in the format of x.xxx decimal. I also provided a +5.12V power supply for the MC68HC908MR16 hardware to provide for 0.005-volt steps for all of 1024 (0 through 1023) steps of the 10-bit analog-to-digital converter (+5.12V / 1024 = 0.005V per step).



■ PHOTO 2. This is a good look at the debugging tools provided by the P&E Cyclone Pro. The voltage readings are shown in the Tera Term Pro window. Using the 10K pot, I dialed in +2.500 volts as the input voltage to the MC68HC908MR16's ADC. Although the results look really bad in raw form, if you average the 20 readings you see, the average voltage works out to be +2.57 volts.

of the MC68HC908MR16. The first method entails reading the 41 pages of the MC68HC908MR16 datasheet describing the care and feeding of the MC68HC908MR16's multi-channel PWM subsystem. Then, write the PWM code you need. The second method does not require any datasheet study and allows you to programmatically set the PWM period and duty cycle in real time units of microseconds or milliseconds.

Behold Listing 4. Just by looking at the code snippet in Listing 4, you already know which of the aforementioned PWM generation methods I used. The song remains the same. I selected the PWM Bean from the Timer folder within the Bean Selector and double-clicked it into my new MR16_PWM project. Configuration of the PWM Bean included renaming the Bean to SERVO, setting a PWM period of 20 mS, and setting up the pulse polarity to produce a high-going pulse.

I compiled the project and inserted the result=SERVO_SetDutyUS function, which was generated in the SERVO.c file. Notice the absence of my omnipresent LED blinker code. There's no need for it here, as I attached an Airtronics 94102 servo to the fourth bit of the MC68HC908MR16's Port E. The source code you are looking at in Listing 4 continually takes the servo rotor to and from both the clockwise and counterclockwise extremes stopping at the center point with each traversal.

ROTATING OUT

All of the additional modifications to the solderless breadboard can be seen in Photo 3. As you can see, I've added an RS-232 port, a potentiometer, and a hobby servo. All of this circuitry could have just as easily been assembled in a point-to-

Doing these things allowed me to add five to the ones variable for each step of voltage measured by the MC68HC908MR16's analog-to-digital converter. The ASCII values 0x30 through 0x39 represent a readable 1 through 9, respectively. So, I initialized all of the digit variables to 0x30 (readable zero) and looked for an overflow to 0x3A after each increment of five operation. The result is an up-counter that converts the value of ANALOG_OutV to a human readable number between 0.000 and 5.120, which represents the voltage applied to the MC68HC908MR16's analog-to-digital converter input pin.

You can observe the caveman

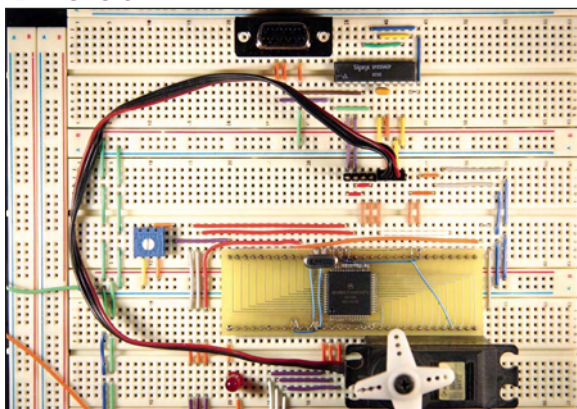
counter's operation by single stepping through the code in debug mode. Once the incoming voltage is converted to human readable form, I used our RS-232 Bean code to send the ASCII voltage reading to a terminal emulator running on a PC. To eliminate missing characters and to make the voltage values a bit easier to read, the ASCII characters need to be paced to the terminal emulator and instead of writing some homebrew delay code, I enabled the Delay100US in the Methods area of the Cpu Bean Inspector.

I recommend you use Tera Term Pro as the terminal emulator. You can get a free copy of Tera Term Pro from the Tera Term Pro home page at <http://hp.vector.co.jp/authors/VA002416/tera-term.html>. You can see the ADC code running and talking to Tera Term Pro in Photo 2.

EASY PWM WITH THE MC68HC908MR16

There are two ways to get a usable PWM signal out

■ PHOTO 3



point or wire-wrap configuration.

Like the A-10 Thunderbolt (affectionately called the Warthog), which is built around a massive Avenger 30 mm seven-barrel cannon, the MC68HC908MR16 is actually built around the gaggle of six PWM outputs it supports. Using the CodeWarrior Development Studio for HC08 v5.0 and its Beans to generate PWM code is a quick and easy way to put PWM to work for you. However, even though I've used Beans exclusively throughout our discussions, you don't have to use Beans to generate working MC68HC908MR16 code with the CodeWarrior Development Studio.

If you prefer to roll your own code from top to bottom and compile using the CodeWarrior Development Studio for HC08 v5.0, you can do so. The Beans are there to help you get your project up and running quickly. As you have seen, you can also generate Beans and then back-track through the generated C source to see how "they" did it.

EDTP Electronics (www.edtp.com) is offering an MC68HC908MR16 mounted on a 64-pin platform just like you see in Photo 3 for those of you that want to build up your own MC68HC908MR16 system. A detailed, close-up shot of the MC68HC908MR16 MCU module is included in the code package I'm providing for download to help you build up an MC68HC908MR16 module like mine.

I'm always available for a question or comments, so please feel free to contact me via email: peterbest@cfl.rr.com I hope that this series of Freescale MC68HC908MR16 columns will help you put the MC68HC908MR16 into your Design Cycle. **NV**

SOURCES

■ Freescale
www.freescale.com
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CodeWarrior Development Studio for HC08 v5.0

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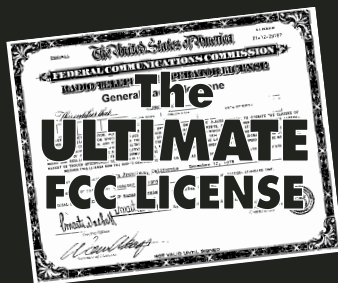
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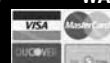
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SPIN THE GAME WAVE™ TO FUN

ZAPiT Games™ has unveiled the *Game Wave™* — a new game system which allows multiple simultaneous play, bundled in a curvy console.

"*Game Wave™* is unique in that it restores a social dimension to games, said Jeff Hurst, ZAPiT Games. "It combines the group interaction of traditional board games with the excitement of interactive video. People find they just have to talk and laugh with each other during play."

Developed by ZAPiT Games, *Game Wave™* is a proprietary DVD-based console that hooks up easily to your TV. It comes with four specially designed color-coded wireless remote units (batteries included), a removable storage dock that holds up to six remotes (additional remotes are optional), and all the gear required for TV connection.

To get play started right away, *Game Wave* comes with *4 Degrees — The Arc of Trivia™*, which offers 25 hours of no-repeat trivia play for up to six people, playing against each other and against the clock with their own color-coded wireless remote. With *4 Degrees*, everyone can play and anyone can win.

The game features rich graphics and hundreds of still and video images, along with digital-quality sound. *4 Degrees* features six categories of questions: Arts, History, Science, Sports, Lifestyle, and Geography. Players get four clues for each question — hence the four degrees — and there is a large range of posers on everything from Cinderella to the Taj Mahal. Scoring is based on the speed and correctness of answers. Players can answer

any time — no more waiting for turns.

Game Wave features a library of other proprietary titles including *REWIND™*, which takes players on a video and photo tour of the world's craziest and greatest events from the past and tests general pop culture knowledge. The game also features special *True or False* and *News or Not* categories.

Other titles available in 2006 include:

- *4 Degrees — Volume 2 Pop Culture*: Offering all-new pop culture trivia challenges in the tradition of *4 Degrees — Volume 1*.
- *4 Degrees — Bible Trivia*: A pictorial quiz of Biblical trivia that will challenge the whole family.
- *Zap 21*: A variation on Classic Blackjack that lets up to six people play at the same time.
- *Letter Zap!*: Players build words from letter cubes, playing against the clock and each other.
- *Piñata*: Players compete against each other and the clock using pictures, sounds, and letter clues to guess the mystery phrase.
- *Roll the Bones*: A series of fun dice games.

Game Wave also plays DVD movies. It retails for \$99.99, which includes the console, four color-coded wireless remotes with batteries, a removable storage dock for the remotes, RGB and S-video cables to hook it up to a TV, and the *4 Degrees* game. Each game title sells separately for \$24.99. Additional remotes retail for \$24.99 for a pair.

Game Wave is available at www.barnesandnoble.com, www.mastermindtoys.com, and the ZAPiT Games

website listed below.

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REDEFINING EASE-OF-USE WITH COMPLETE \$20 MCU DEVELOPMENT TOOL

Texas Instruments Incorporated (TI) now offers the eZ430-F2013, the world's smallest, complete microcontroller (MCU) development and evaluation tool, available for only \$20. In a compact Universal Serial Bus (USB) stick form factor, the eZ430 tool allows new users to evaluate the MSP430 MCU architecture in minutes and, for the first time, gives experienced developers all the resources they need to complete an entire MSP430F20xx project from start to finish. For more information on the new eZ430-F2013 tool, go to TI's website.

"We take our customer's time and development costs very seriously," said Mark Buccini, TI's advanced embedded controls director of marketing. "The eZ430 is not only great for fast MCU evaluation, but it is also the only full MCU development tool contained in a USB stick available today. With the eZ430, developing embedded design projects with MSP430F20xx MCUs is a snap."

The eZ430-F2013 tool connects to a standard PC USB port and is self-powered, requiring no extra cables or power supplies. Contained within the USB stick is an emulation interface board and an easily removable MSP430F2013 target board, which differentiates the eZ430 from other fixed-function evaluation systems. Using TI's



innovative Spy bi-wire debug interface, only two signals — power and ground — are needed to connect the emulation interface and target, enabling very compact, high-performance MCU development in a low-cost environment.

The emulation board communicates with the MSP430 MCU target devices' emulation logic non-obtrusively, in-system and subject to the exact same electrical characteristics as the final application, which eliminates costly, time-consuming intermediate steps. This board uses a TI TUSB3410 for the USB interface and a TPS77301 to provide 3V regulation to the system. The target board makes all 14 MSP430F2013 pins available on an industry standard 0.1 inch through-hole header and includes an LED for immediate development feedback.

The eZ430 tool includes a free IAR Kick Start Embedded Workbench IDE containing a debugger, assembler, and C compiler. This is the same IDE currently used for all MSP430 MCUs, meaning designers can leverage existing code and expertise. To jump-start new projects, users can tap into over 100 free C and assembler source code examples that are available from TI's website.

The MSP430F2013 MCU is part of the recently introduced MSP430F20xx series, operating up to 16 MIPS in a robust failsafe environment with no external components. The MSP430F20xx series' fully programmable clock system is stable over temperature and voltage, providing wake-up from an industry-leading 500 nano-amp standby to full-speed operation in less than one micro-second. Ultra-low power combined with on-demand high-performance lets designers tune their systems to stay in standby longer so their applications conserve more power and use smaller, lower cost batteries.

Operating from 1.8 to 3.6V, MSP430F20xx MCUs allow direct battery operation and are available in a 14-pin footprint as small as 4x4mm. A choice of converters includes an analog comparator for very cost-sensitive applications, a 200 kilosamples per second (KSPS), 10-bit analog to digital converter (ADC) for real-time signal processing, or a 16-bit sigma-delta ADC for high-precision systems. All devices

include an enhanced watchdog timer for extreme reliability, a multi-function 16-bit timer and in-system programmable Flash for greater design flexibility and field upgrade capability. With 128B of RAM, a full-featured 16-bit RISC CPU, and complete development in C, developers can reuse existing MSP430 instruction set architecture (ISA) libraries for faster time-to-market.

From ultra low-power MSP430 devices and 32-bit general-purpose TMS470 ARM7-based MCUs to high

performance TMS320C2000™ digital signal controllers, TI offers designers a broad range of embedded control solutions. Designers can also accelerate their design to market by tapping into TI's complete software and hardware tools, extensive third party offerings, and technical support. For more information on TI's broad range of controllers, see www.ti.com/mcu

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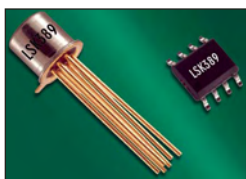


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MONOLITHIC DUAL JFETs

Linear Integrated Systems (LIS), a leading full-service manufacturer of specialty linear semiconductors, announces the immediate availability of its LSK389 series of InV N-Channel Monolithic



Dual JFETs. The LSK389 series is a monolithic dual version of the recently released LSK170 Single N-Channel JFET. This family of ultra low noise dual JFETs was specifically designed to provide users a better performing, less time consuming, and cheaper solution for obtaining tighter IDSS matching, and better thermal tracking, than matching individual JFETs. Available packaged in surface mount, ROHS compliant versions, the LSK389 is an ideal improved functional replacement for the through-hole Toshiba 2SK389,

within space limited circuits for audio and instrumentation applications.

The LSK389's features incorporate three grades of IDSS: 2.6-6.5 mA, 6.0-12 mA, 10-20 mA, with an IDSS match of 10%, a gate threshold offset of 20 mV, a voltage noise (en) of 1 nV/Hz @ 1 kHz, 2 nV/Hz @ 10 Hz typical, with a gain of 22 ms, and 22 pF of capacitance.

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The LSK389 series is packaged in surface mount SOIC-8 and thru-hole TO-71 six lead packages and lead-free, ROHS compliant versions are available.

"Our new LSK389 series features a unique design construction of interleaving both JFETs on the same piece of silicon that provides excellent matching and thermal tracking, as well a low noise profile having nearly zero popcorn noise," says Dr. John Hall, Linear Integrated Systems founder and president.

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FIRMWARE-ONLY USB DRIVER

Objective Development has released a new version of their firmware-only USB driver for Atmel's AVR microcontrollers (AVR-USB), just in time for the driver's one year anniversary. This version adds new licensing options and free USB Product IDs bundled with all license types, even with the free Open Source compliant license.

AVR-USB is targeted to small companies and hobbyists designing hardware with USB connectivity based on standard AVR microcontrollers. It implements a low speed USB device in the same way as a Software-UART implements asynchronous serial data transfer. The only hardware resources needed from the AVR microcontroller are two I/O pins; one of them must be an edge triggered interrupt.

Since RS232 ports have become rare in modern computers, USB is the method of choice for connecting various gadgets to the PC. The major drawback for small companies and hobbyists is the relatively large upfront investment which is usually required to work with USB: You need to buy a USB Vendor ID from usb.org (currently \$1,500 US) and maybe a new development system for USB capable microcontrollers. Furthermore, microcontrollers with USB are often available in SMD packages and large quantities only, making things even harder for small startup companies and hobbyists.

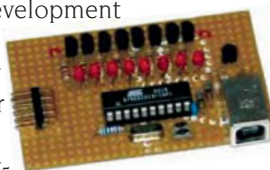
AVR-USB addresses all these issues. It comes with an Open Source license, a USB Product ID which can be used for free (shared according to the certain implementation rules), it is based on the free GNU compiler as its development environment, and works with low-cost

AVR microcontrollers which are available in DIP packages. The PC side driver can be constructed with libusb, a free USB abstraction library which is available for Windows, Linux, Mac OS X, and BSD Unix. No Microsoft SDK or development environment is required for Windows driver development.

Two affordable commercial license types are available for those who cannot agree to the publication requirement of the Open Source license. The entry level license for 199

EUR allows using AVR-USB in up to 150 units and comes with a dedicated USB Product ID for exclusive use. The professional license for 500 EUR has virtually no limit in the number of units (fair use) and comes with two dedicated USB Product IDs. AVR-USB can be downloaded as part of an example application at www.obdev.at/products/avrusb/powerswitch.html

Objective Development
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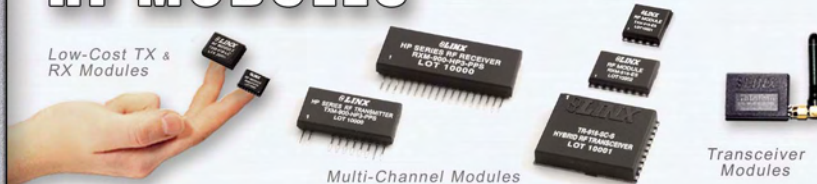


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■ THIS MONTH'S PROJECTS

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Get Motivated56

■ LEVEL RATING SYSTEM

To find out the level of difficulty for each of these projects, turn to our ratings for the answers.

●●●● Beginner Level

●●●● Intermediate Level

●●●● Advanced Level

●●●● Professional Level

I remember the day when getting a single digital signal out of my computer was as easy as sticking a wire into the parallel port and remembering its address.

If you set a bit high, the corresponding pin on the parallel port would go high, and stay high until you told it to do otherwise. You could likewise read the state of any of the input pins, much like reading or writing to I/O pins on microcontrollers today.

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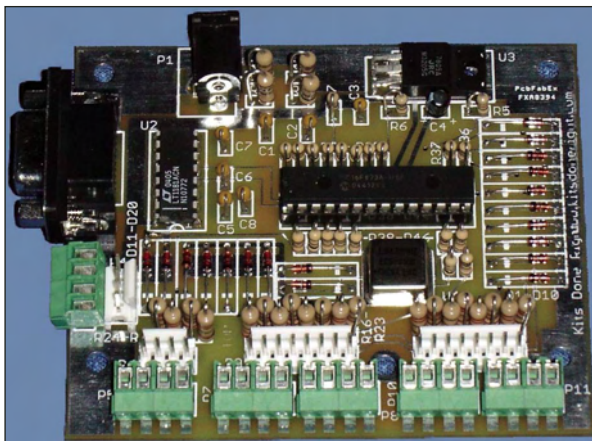
When I first learned the art of manipulating the I/O pin on my computer's parallel port, I was in techno-heaven! Suddenly, connecting my projects to the computer and adding software became a breeze. I no longer had to try and build complex timers to operate my homebrew sprinkler system controller — I could simply use my computer to turn on a transistor which would drive my sprinkler valve solenoid.

I could then fully customize my sprinkler system to water the established grass on the right days at the right times (even with very

strange watering restrictions), and also give my newly planted grass a five minute drink every half hour from 11am to 3pm. It seemed to me that any project could benefit from an interface with my computer's parallel port — home security systems, automatic lighting, and weather stations, to name a few.

This all changed with the advance of Microsoft Windows. No longer could I directly address my parallel port, and when I finally did figure out how to put data on it, I just got errors about not having a printer connected. I was able to make an LED blink on and off quite randomly, but it quickly became evident that I was going to need some other method for getting data into and out of my computer.

For a long time, I just didn't have a convenient (or inconvenient) way of utilizing the power of



■ **FIGURE 1. Finished Data Acquisition Board.**

my PC in my projects. I looked around at some other products and software, but none of them really seemed to fit my need. I needed something that I could use over and over again in a variety of different applications; a single board that could interface with several different projects at once, but was also cost-effective enough to justify dedicating it to a single project if that project demanded it.

I finally began to develop my own computer interface board, which would transform a standard serial port into something more like the old parallel ports from the days of DOS.

What Does the Board Do and How Does it Work?

The Data Acquisition Board (DAQ) converts standard serial I/O from a PC into a 20 pin parallel I/O bus. Each of the 20 I/O pins is individually configurable as an input or an output. You can read the state of each pin, or change the state if it's configured as an output, about a 1,000 times per second.

There is also the potential, with some additional firmware, to add up to five analog inputs with 10 bits of resolution. You can communicate with the board using binary commands or text commands. The text commands are easy to use, and can even be executed with Microsoft HyperTerminal. The binary commands require a better understanding of ones and zeros, but are much faster than the text commands. The board operates at bit rates up to 115.2K, and down to 300.

Why Did I Go With a Serial Port Interface Instead of a Parallel Port or USB?

Although many will disagree with me, there are a few advantages to a serial connection:

1. *Serial cables are cheap* — you can make your own without too much trouble, and if you're not worried about noise, you can sploog one together with just three wires: TX, RX, and GND.

2. *At the lower bit rates, you can use serial cables 50 ft or longer.* This has enabled me to connect some projects to the computer that would not otherwise have been practical without a wireless setup.

3. *A computer's serial port is easy to access;* you can use virtually any programming interface, and all you need are the standard drivers already installed on your PC.

Hardware Design

The DAQ is built around the PIC16F873A microcontroller (see the schematic in Figure 2). I used a 1.8432 MHz crystal oscillator for the clock because it's compatible with most of the standard serial port bit rates. You may notice that 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 all divide into 1.8432M evenly. Because of this, the DAQ can operate at all those bit rates with virtually no error.

RC6 and RC7 (pins 17 and 18 on the PIC) are the TX and RX lines for the serial communications; you can't just connect those two pins directly up to your PC however. The PIC is powered by a single +5V power supply, but a standard serial interface requires a negative voltage, as well as a positive voltage — a logical high is negative and a logical low is positive. Likewise, the transmit line coming from your computer swings positive and negative — if it was connected directly to the PIC, it would most certainly damage the chip.

The TX signal from the PIC needs to be inverted and swing positive and negative, and the RX going to the PIC needs to be inverted and go from 0V

to +5V. I decided to go with the LT1181ACN RS232 driver IC to interface between the microcontroller and the computer. This is a handy little IC! When the TX pin on the PIC goes high, the TX out pin on the LT1181 goes to about -8V. Likewise, when the TX pin on the PIC goes low, the LT1181 goes to about +8V. No additional power supply needed!

How do you get + and -8V out when you only have a +5V power supply? The LT1181 not only does the inverting for you, it also has a charge pump on the chip to generate a + and - voltage supply. Capacitors C5-C8 are filter caps for the switching network on the IC.

The MCLR pin on the PIC (pin 1) and its associated components (R5, R6, and C4) don't make a very interesting circuit. The circuit simply causes the MCLR pin to go high a short time after power-up which, in turn, causes the PIC to reset. I did want to pass on, however, that I tried a few different resistor and capacitor values before going with the ones I did.

A 10 μ F cap for C4 intuitively seems very large for this application, however, smaller values for this cap cause a very frustrating problem. The DAQ would be operating just fine, and then it would freeze up for no apparent reason. I went over and over my firmware trying to find the never-ending loop I was sure was causing the problem, but I never found it. I checked and rechecked every solder joint trying to find the loose wire, but I never found that either.

After hours of troubleshooting and getting nowhere, it finally occurred to me that the PIC may be resetting intermittently. After a little more investigation, I found this to be the case. I then started experimenting with different values for R5 and C4; 10 kohms and 10 μ F is what I ended up with. Again, a 10 μ F electrolytic capacitor doesn't seem like the right answer to me, but I've used the DAQ board

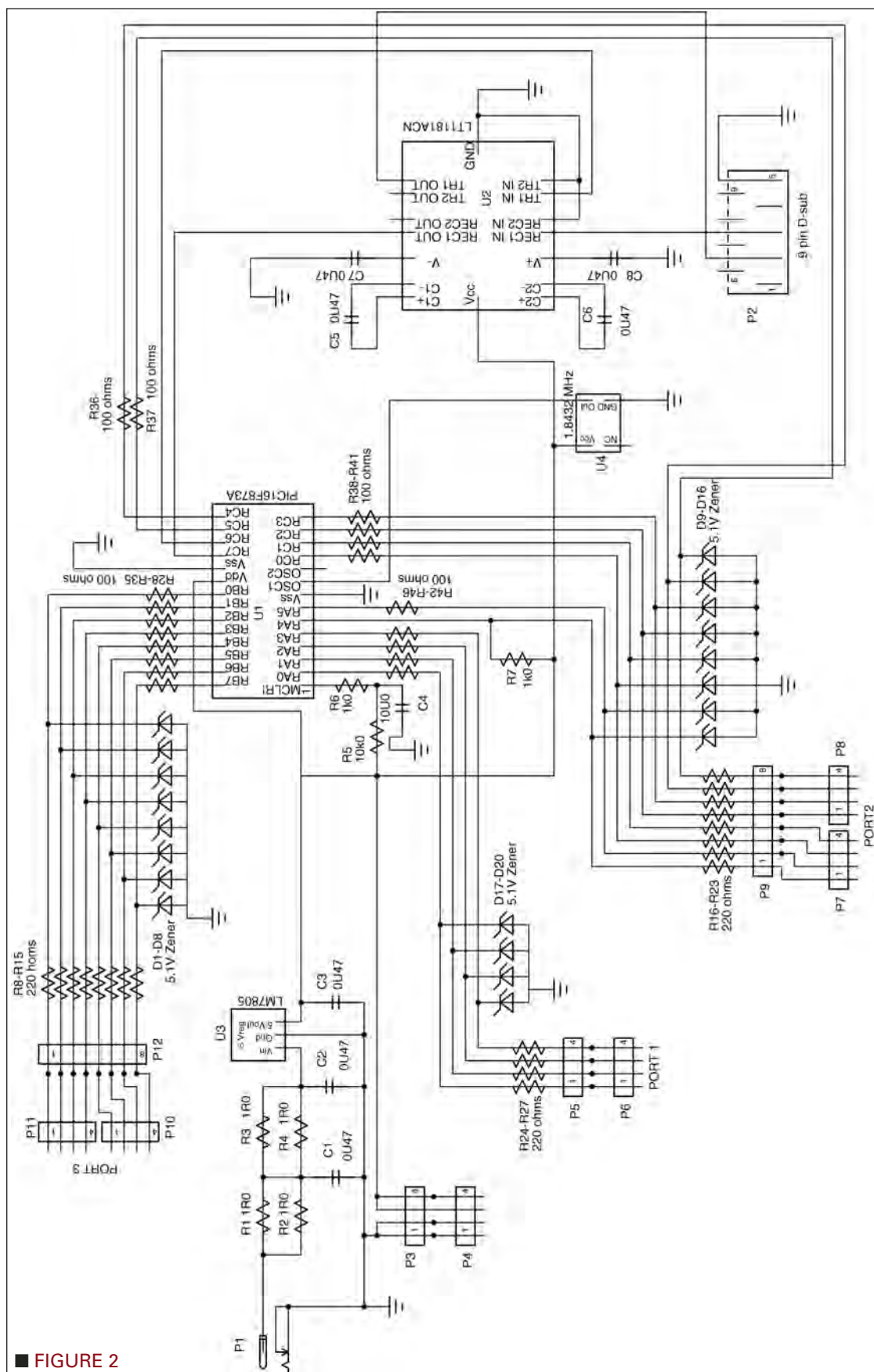


FIGURE 2

quite a bit in many different applications over the past year since I made the change, and I haven't run into that problem again.

The rest of the pins on the PIC (besides the power supply pins) are used as digital I/O. In the original design, each connector to the outside world was directly connected to its corresponding pin on the PIC. This worked very well and I didn't have any problems until the first time I accidentally applied a +12V signal to an input pin. The PIC didn't like that too much, and promptly quit working all together.

Since then, I've added some protection. As illustrated in the schematic, each I/O pin has two resistors in series between the connector and its pin on the PIC. Between the two resistors is a 5.1V zener diode to ground. The 220 ohm, 1/2 watt resistor in combination with the 5.1V zener should protect against a +15V signal applied to the input indefinitely, however the resistor will get hot. Any more voltage applied for an extended period of time may cause the resistor to "let out its smoke." The 100 ohm resistor limits the current from the PIC,



more interesting.

The first byte in a serial transmission always has the command number (if you're using binary commands) or is a textual character. The rest of the main program loop just checks that first byte to see what to do next.

If the first byte is a binary command, then the program goes to the corresponding function which executes that command. If the first byte is a textual character, then the program goes to the memory location marked by 'cmd_text' where the rest of the command string is received, processed, and finally the command is executed by the processor.

Assembly Instructions

You can find detailed assembly

and test instructions by going to www.kitsdoneright.com/daq.html and clicking on the 'Assembly instructions' link. You will also find a parts placement diagram, the images for the PCB (should you decide to make your own), and the parts list on the website. You can also download the complete firmware (DAQ.asm) so you can make your own custom modifications to the code.

The hex file is provided for download so you can just program the PIC without having to first compile the code. You can purchase a preprogrammed PIC, as well as the printed circuit board or the entire kit on the website. The website has many other resources, including programming examples and a utility program for testing your completed DAQ.

Possible Improvements

I use the DAQ board quite a bit, and it works very well for me, but there are a few improvements that could be made. The most obvious improvement would be to convert it to USB. This would greatly increase the speed of the DAQ, although it would also decrease the distance your project can be from the computer.

In regards to protection, you may have noticed that the DAQ inputs are protected relatively well to voltages over +5V, but not as well if you apply a negative voltage. In this case, the input pin would be clamped at -.6V, overstressing the PIC by .3V more than the manufacturer's specification allows for.

The addition of Schottky diodes in parallel with the zeners might be a good idea to clamp any negative voltages to -.2V. One other improvement that wouldn't take more than some additional firmware would be the addition of analog inputs. Turning PORT1 pins 0-3 and PORT2 pin 0 into analog inputs wouldn't be too difficult if you're using the binary commands. If you want to use the text commands, however, you will have to convert the binary number produced by the ADC into text — doable, but a little more difficult. The good news is, there's lots of room left in the PIC to add features. The current program only takes up about half of the program memory available. **NV**



PARTS LIST

RESISTORS

- ☐ R1-R4
- ☐ R6, R7
- ☐ R5
- ☐ R8-R27
- ☐ R28-R46

SUPPLIER

Panasonic
Panasonic
Panasonic
Panasonic
Panasonic

PART NO.

ERD-S1TJ1R0V
ERD-S2TJ102V
ERD-S2TJ103V
ERD-S1TJ221V
ERD-S2TJ101V

DESCRIPTION

1 ohm, 1/2 watt, 5%, Carbon Film
1K ohm, 1/4 watt, 5%, Carbon Film
10K ohms, 1/4 watt, 5%, Carbon Film
220 ohm, 1/2 watt, 5%, Carbon Film
100 ohm, 1/4 watt, 5%, Carbon Film

CAPACITORS

- ☐ C1-C3
- ☐ C4
- ☐ C5-C8

AVX Corporation
Panasonic
AVX Corporation

SA305E474MAA
ECE-A1CKS100
SA305E474MAA

0.47 μ F, 50V, Ceramic
10 μ F, 16V, Electrolytic
0.47 μ F, 50V, Ceramic

DIODES

- ☐ D1-D20

Fairchild

1N751ATR

5.1V zener, 1/2 watt

ICs

- ☐ U1
- ☐ U2
- ☐ U3
- ☐ U4

Microchip
LinearTechnology
NJR
ECS

PIC16F873A-I/SP
LT1181ACN
NJM7805FA
ECS-2100A-018

Microcontroller
RS232 Driver/Receiver
Voltage Regulator, 5V, 1.5A
1.8432 MHz Crystal Oscillator

CONNECTORS

- ☐ P1
- ☐ P2
- ☐ P3, P5, P7
P8, P10, P11
- ☐ P4, P6
- ☐ P9, P12

CUI, Inc.
Kobiconn
Phoenix Contact
AMP
AMP

PJ-202A
152-3409
1984785
640456-4
640456-8

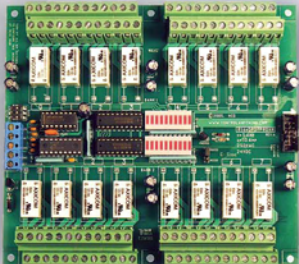
Power Jack, 2.1 mm, PCB mount
9 pin D-sub Receptacle
Terminal Block, 3.5 mm, Four Position
Vertical Header, Four Position, .100 in
Vertical Header, Eight Position, .100 in

MISCELLANEOUS

- ☐ AC Adapter, 9 VDC, 300 mA
- ☐ Xicon, 412-109033
- ☐ Power Supply

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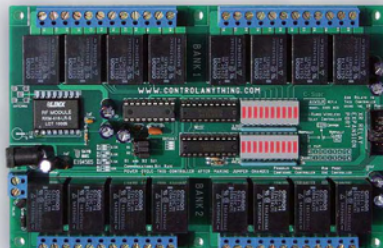
The Ultra Series Offer RS-232 or Wireless Data Collection and Control with 16 On-Board Relays, 16-Channels of Digital I/O and 8 Channels of 10-Bit A/D. Expandable to 512 Relays, 4096 Inputs, and 96 Channels of 12-Bit A/D. Optional LCD Shown.



RS-232 or Wireless Data Collection and Control without the Relays. Expandable to 512 Relays using XR Expansion Relay Boards, Expandable to 4096 Inputs and 96 Channels of 12-Bit A/D.



Wireless 4-Channel Relay Controller with 20A 250VAC Switching. Operates up to 3,000 Feet Away, XR Expansion Allows you to Control up to 128 Relays.



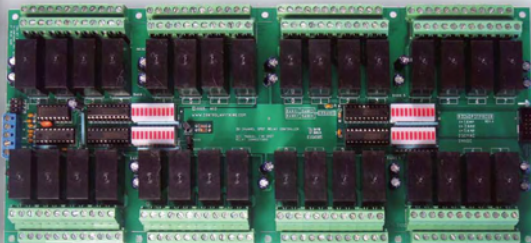
Wireless 16-Channel Relay Controller with 10A 250VAC Switching. Operates up to 3,000 Feet Away, XR Expansion Allows you to Control up to 128 Relays.



This Expansion Module Adds 48 Channels or Contact Closure Inputs to the Ultra Series Controllers (shown above). Chain More Inputs End to End, Expandable to 4096 Contact Closures Inputs.



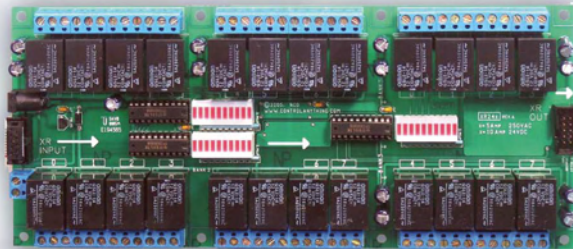
This Expansion Adds 16 Channels of 12-Bit A/D Inputs to the Ultra Series Controllers (shown above). Chain More Inputs End to End, Expandable to 96 Channels of A/D. Can Also be Chained to the Contact Closure Expansion Shown Above.



RS-232 Relay Controller with 32 Channels of 5A DPDT Relays, Expandable to 256 Relays. 7 Baud Rates up to 115.2K. 16 User Programmable Timers Activate Relays for User-Set Duration. Suitable for Duration, Watchdog and Server Reboot Applications.

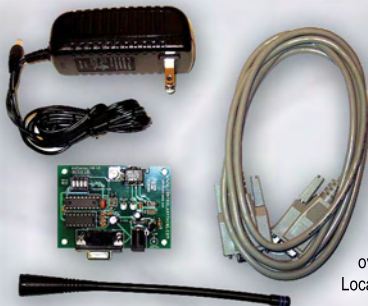
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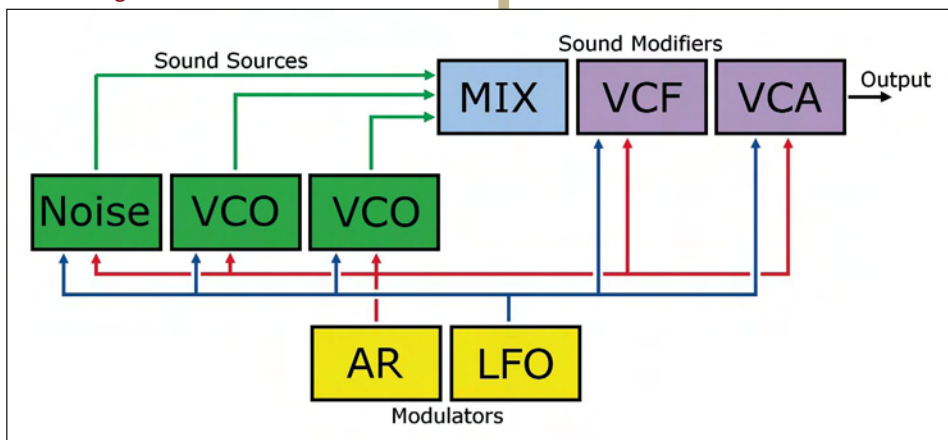
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Analog music synthesizers — the kind with all the knobs and patch cords — were extremely popular 10 to 15 years ago. In those days, the name Moog (pronounced like vogue) was a household name. Digital music synthesizers eventually overshadowed the popularity of the analog ones and a steady stream of ever-improving computer-driven instruments continues to line the shelves of music stores.

Today, however, whether due to nostalgia or the same thing that drives old clothes back into style, analog synthesizers are seeing a resurgence of popularity.

■ FIGURE 1. Sound Lab Mini-Synth Block Diagram.



BUILD THE SOUND LAB MINI-SYNTH

SOUND SYNTHESIZER

This article will show you how to build a very cool analog sound synthesizer. You will learn about analog sound generation, have a great project building experience, and have hours of sound synthesizing fun. I would say that the difficulty of this project is somewhere between an intermediate and advanced level. It involves making a printed circuit board, fabricating a front panel and case, and a good bit of wiring and soldering. I think you will find it well worth the effort. I am making PC boards available for sale from my website, if you would rather not etch one yourself. I invite you to visit my website at www.musicfromouterspace.com and hear the Sound Lab Mini-Synth for yourself.

Introduction

Refer to Figure 1. The Sound Lab Mini-Synth is a battery-powered analog sound synthesizer complete with two voltage controlled oscillators (VCOs), a white noise source (Noise), a mixer (MIX), one voltage controlled state variable filter (VCF), one voltage controlled amplifier (VCA), an attack release envelope generator (AR), and one low frequency oscillator (LFO). Together, these modules provide sound sources, sound modifiers, and modulators — the tools to create a wide range of electronic sounds. Let's take a look at each module in detail.

Attack Release Envelope Generator

The Attack Release Envelope Generator (AR) is one of the Sound Lab's modulators (see Figure 2). It produces a voltage which rises and falls at a rate set by the attack and decay pot settings, respectively. The higher the knob setting, the longer the rise (attack) or fall (decay) time of the voltage produced by this module.

Sounds generally have a characteristic envelope or overall shape. The envelope of the sound of a bell, for instance, has a fast

attack and a decay that depends on the size of the bell. A violin can be played so that the sound has a very slow attack and decay or a fast pizzicato attack and subsequent fast decay. The Sound Lab's AR can be used to control the VCA (which modifies the amplitude of the unit's sound sources), the VCF (which modifies the harmonic content of the unit's sound sources), and the VCOs (the pitch sources for the unit).

With S2 in the off state and S3 set to "Trig'd," the circuit functions as follows. When S1 is momentarily pressed, it discharges C2 (to about 1.6 volts) through R2, which causes pin 2 of IC1-A to go high. This pushes a positive pulse through C1 and D1,

IC1-E and IC1-F. IC1-F pin 12 goes high and C3 begins to charge at the rate set by the Attack pot R10 from -8 volts to about 6.5 volts (this voltage is buffered by the IC2-B voltage follower), at which point IC1-B's output goes low and IC1-C's output goes high and the IC1-E/IC1-F flip-flop is reset by the high logic level presented to pin 13 via D5. (Whew!) This causes IC1-F pin 12 to go low and discharge C3 at a rate determined by R11.

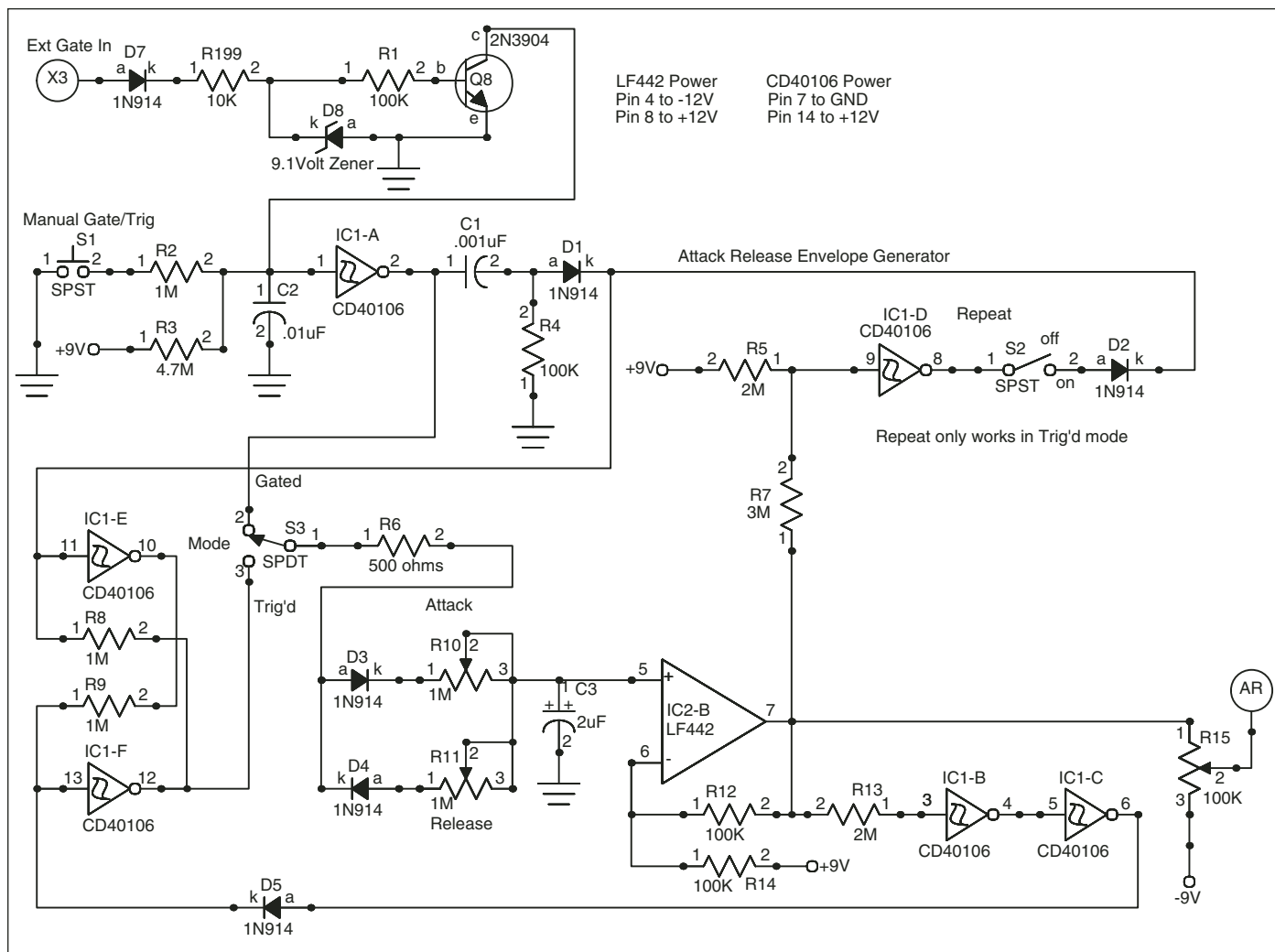
When the Repeat switch is on and the voltage at IC2-B is lower than -6 volts, then IC1-D pin 8 goes high and sets the IC1-E/IC1-F flip-flop again, thus, causing the cycle to begin again and subsequently repeat. Notice that I am allowing negative voltages to reach the inputs of the Schmidt trig-

gers, but that they are protected from drawing high current through their internal protection diodes during that time by the high value resistors in series with their inputs.

When S3 is in the "Gated" position, the repeat function is disabled. In this configuration, a high level is presented to the "Attack" diode/pot combo as long as S1 is held pressed (because the output of IC1-A is high when S1 is held pressed). Gate mode allows C3 to charge from -8 volts to about +8 volts maximum.

When S1 is released, a low level is presented to the "Release" diode/pot combo (because the output of IC1-A is low when S1 is not pressed). The

■ FIGURE 2. Attack Release Envelope Generator Schematic.





output of IC2-B is fed to R15, the AR Envelope output level adjustment pot. The circuit point "AR" is the wiper of R15, which is fed to the AR-Gen switches of the modules.

While contemplating this circuit, remember that the inverters are Schmidt triggers and that their inputs must go lower than a third of the supply voltage before their output goes high, and then the input must go to greater than two-thirds of the supply voltage before the output goes low. This characteristic is known as hysteresis.

The zener diode on the external gate is meant to protect against gate signals greater than nine volts. When the external gate is high, Q8 will discharge C2 the same way the switch S1 does.

NOTE: If you don't plan to use the

■ **FIGURE 3. LFO, Noise Source, and $\pm 9V$ Battery Power Supply Schematic.**

external gate capability of the device, you can eliminate the following components: D7, R199, R1, D8, Q8.

Low Frequency Oscillator, Noise Source, and $\pm 9V$ Battery Power Supply

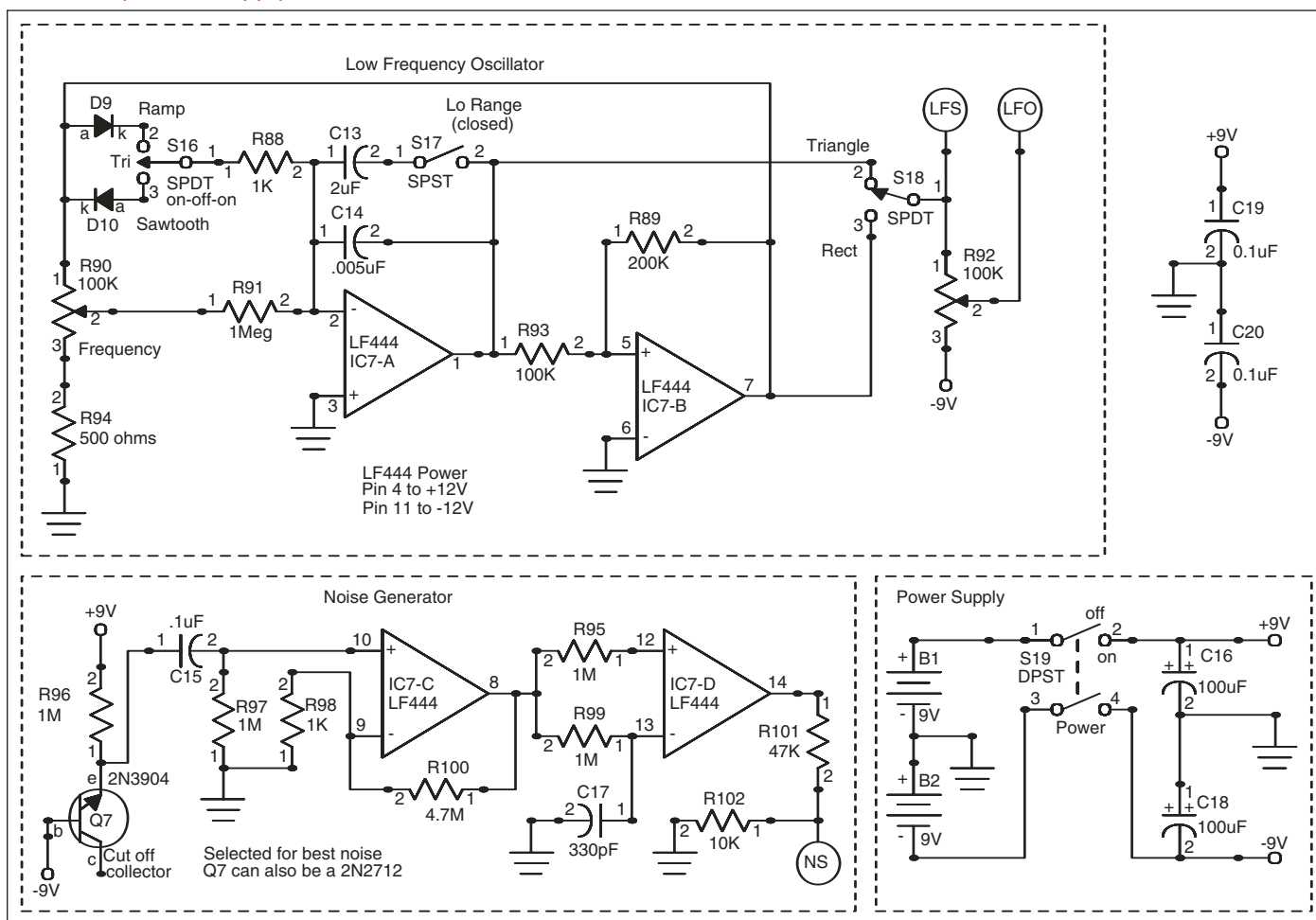
The low frequency oscillator is another modulator used to produce cyclic voltage changes with which the unit's sound generators and sound modifiers can be controlled (see Figure 3). By applying the LFOs triangle wave to the control voltage input of a VCO, you will produce the sound of a siren. If you increase the frequency of the LFO enough, you will begin to hear bell-type tones as the oscillator being modulated starts to produce a characteristic ring-modulated sound. The noise generator is used to produce non-pitched sounds like rain,

wind, or steam and, of course, the batteries power the unit. By using the recommended low power op-amps, the batteries will last a long time.

Let's discuss this part of the circuit. Two 2N3904s walk into a bar. One makes a lot of noise and gets thrown out while the other one sits and quietly drinks his stout. The punch line? Some transistors are noisier than others. So how do we get noise out of *any* 2N3904? We do it with this circuit.

Notice that we do the usual ... reverse bias a low V(ebo) emitter base junction, listen to the junction through C10, and a gain of about 1,000. If this transistor is whispering, it is still whispering into a lot of gain. This circuit does not care if this transistor is in a confessional — you are going to get at least 100 mV of noise from the first stage.

We take whatever we are getting



The Sound Lab Mini-Synth Sound Synthesizer

from the first LF444 and feed both inputs of a second LF444 through two 1M resistors. We hang a capacitor off of the inverting input and — voila — the inverting input always lags the non-inverting one. As the noise voltage is taking its time trying to go up and down (due to the cap) on the inverting input, it is racing up and down on the non-inverting input. This results in the voltage on the non-inverting input randomly being higher or lower than the voltage on the inverting input as the noise voltage randomly changes. Since the op-amp is wired as a full blast comparator, its output is swinging up and down between the voltage limits of the LF444 in time to the noise fluctuations. Varying the cap and varying which input you hang the cap on will change the characteristics of

the noise at the output of the second stage.

The LFO is a simple inverting integrator with positive feedback. IC7-A ramps up when its input is held low and then ramps down when the input is brought high. IC7-B is a comparator that senses the output of IC7-A and goes high when the voltage out of IC7-A goes above its positive threshold. This high voltage is fed back to the input of IC7-A, which goes low in response until IC7-B goes low and then the cycle continues.

Switch S16 and Diodes D9 and D10 control the shape of the LFO's waveform (centered for triangle either pole gives ramp and sawtooth). In low range (S17 on), a 2 μ F cap (C13) is placed in parallel with the integrator capacitor (C14) to reduce the range of frequency provided by the Frequency

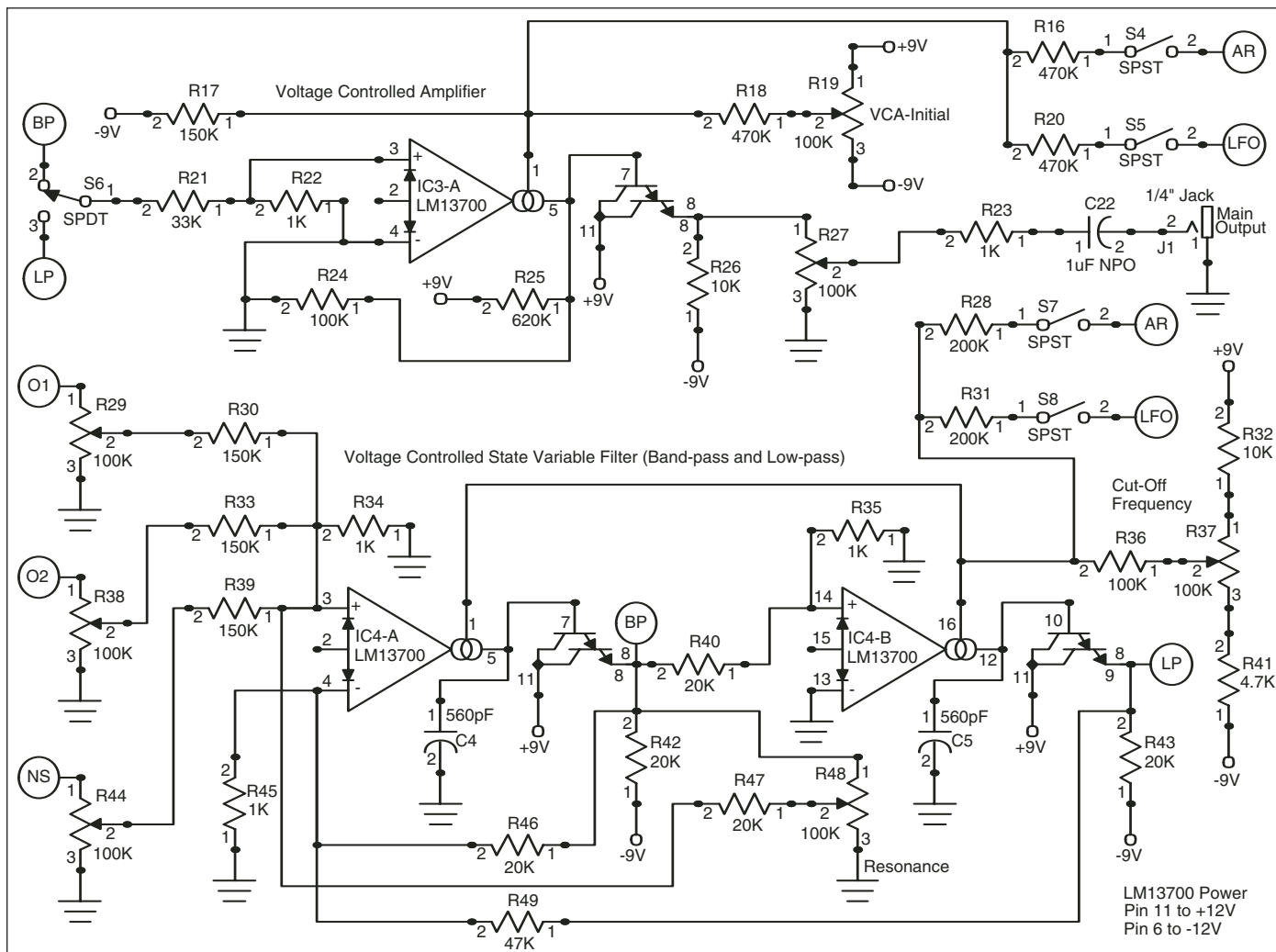
pot R90.

Two nine-volt batteries power the Sound Lab and the two by-pass caps absorb any large current spikes generated during operation. All of the circuits in the Sound Lab together draw less than 6 mA.

Voltage-Controlled Amplifier and Voltage-Controlled Filter

The VCA and VCF are sound modifiers (see Figure 4). The VCA allows you to modulate the amplitude of the unit's sound sources with the AR and the LFO. It can produce tremolo effects, ring modulation, and amplitude envelopes. The VCF lets

■ **FIGURE 4. Voltage-Controlled Amplifier and Voltage-Controlled Filter Schematic.**





you modulate the harmonic content of the unit's sound sources. It produces wah-wah sounds, dripping water, howling wind, or growling oscillators. VCFs are my favorite synthesizer modules.

These two circuits are practically straight out of the National Operational Amplifiers Data book data sheet for the LM13700 Dual Operational Transconductance Amplifier (OTA). The transconductance characteristic of these op-amps makes them perfect for VCAs and VCFs.

In the VCA, the control voltage controls the current flow through the amp and subsequent level of the sig-

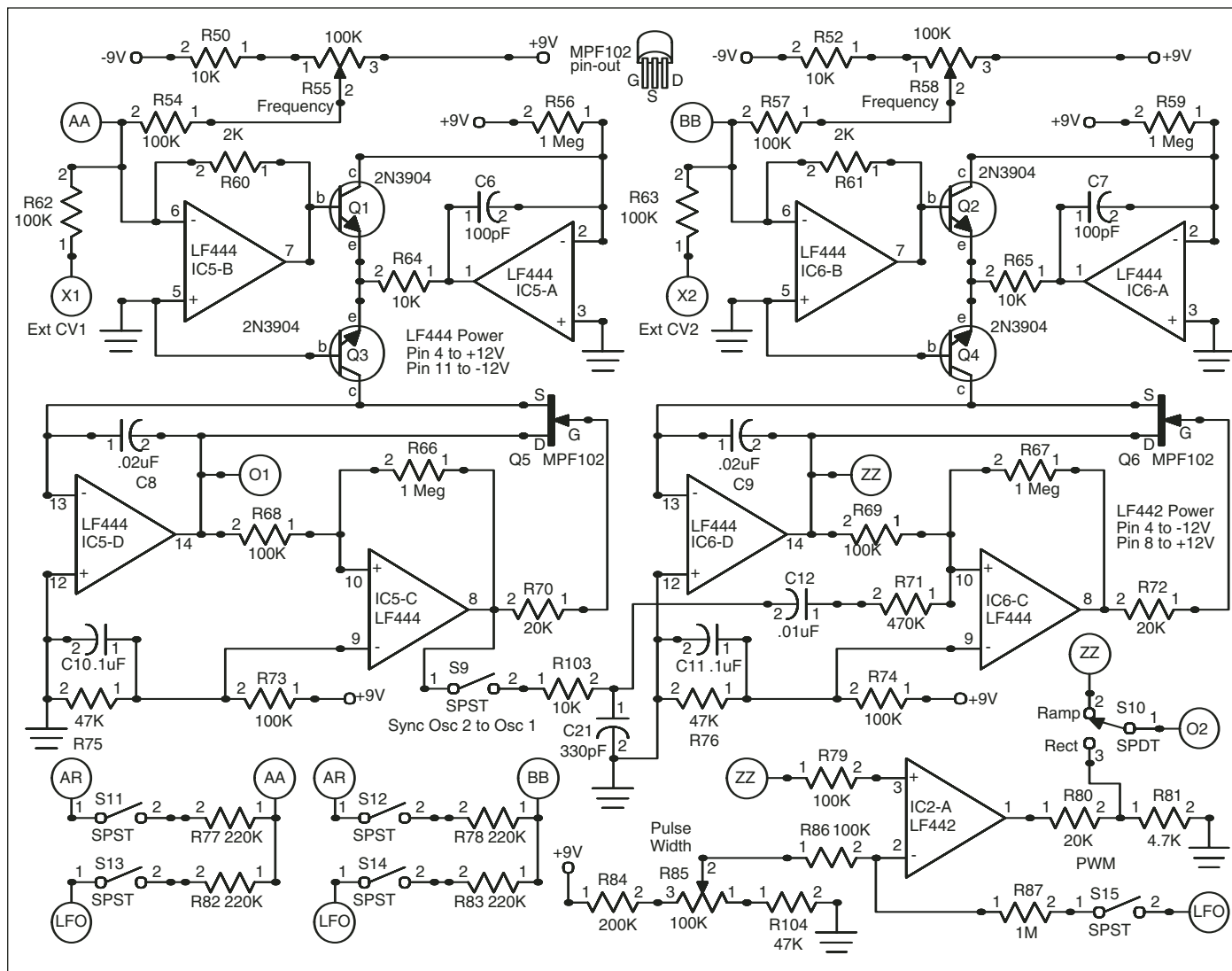
nal at the output. S4 switches the AR Gen control voltage on or off. When on, the level of the AR Generator output pot determines how much the AR Generator controls the signal amplitude at the output of the VCA. S5 switches the LFO control voltage on or off. When on, the level of the LFO output pot determines how much the LFO controls the signal amplitude at the output of the VCA. R19 controls the initial amplitude at the output of the VCA. When S4 or S5 is on, it is best to turn R19 off or nearly off.

In the VCF, the OTAs operate as voltage-controlled resistors that change the pass-band (in band pass mode) and cut-off frequency (in low pass mode) from low (for low control voltage) to high (for high control volt-

age). The resonance control adjusts the feedback around the circuit and, thus, the gain at the cut-off frequency. At high resonance settings, the filter rings, adding harmonics to the filtered signal which give the classic synthesizer wahhhhhh sound when the cut-off frequency is swept from low to high.

The filter also acts as the mixer as all of the signal sources are presented to its input via attenuation pots (R29, R38, and R44). The input to the VCA is either the low pass output or the band pass output determined by the setting of switch S6. S7 switches the AR Gen control voltage on or off. When on, the level of the AR Generator output pot determines how much the AR Generator controls the

■ **FIGURE 5. Voltage-Controlled Oscillators Schematic.**



The Sound Lab Mini-Synth Sound Synthesizer

cut-off frequency of the VCF. S8 switches the LFO control voltage on or off. When on, the level of the LFO output pot determines how much the LFO controls the cut-off frequency of the VCF. R37 controls the initial cut-off frequency of the VCF. When S7 or S8 is on, it is best to turn R37 off or nearly off.

Voltage-Controlled Oscillators

The oscillators are the heart of any synthesizer and they provide the main sound generating capability (see Figure 5). Just about every sound you hear has some pitch to it — a voice, a trumpet, an airplane, etc. The pitch may be modulated or modified, but it is there a great majority of the time.

The Sound Lab uses two voltage controlled ramp oscillators to provide pitch sources. IC5-B and IC5-A and associated transistors and components comprise a linear voltage to logarithmic current converter. The control voltages that are summed by IC5-B range from -8 to 8 volts. The resulting current ranges from around 1 μ A to 1 mA and, since the oscillators go up approximately one octave every time the current doubles, this gives the oscillator a nice range from a sub-audible 0.6 Hz to about 8.3 kHz.

Oscillation occurs because as the current is pulled out of the input of integrator IC5-D, its output goes high until IC5-C (comparator with hysteresis) pin 8 goes high and shorts the integrating capacitor (C8), which causes the cycle to begin anew and subsequently repeat. IC6 is used in a

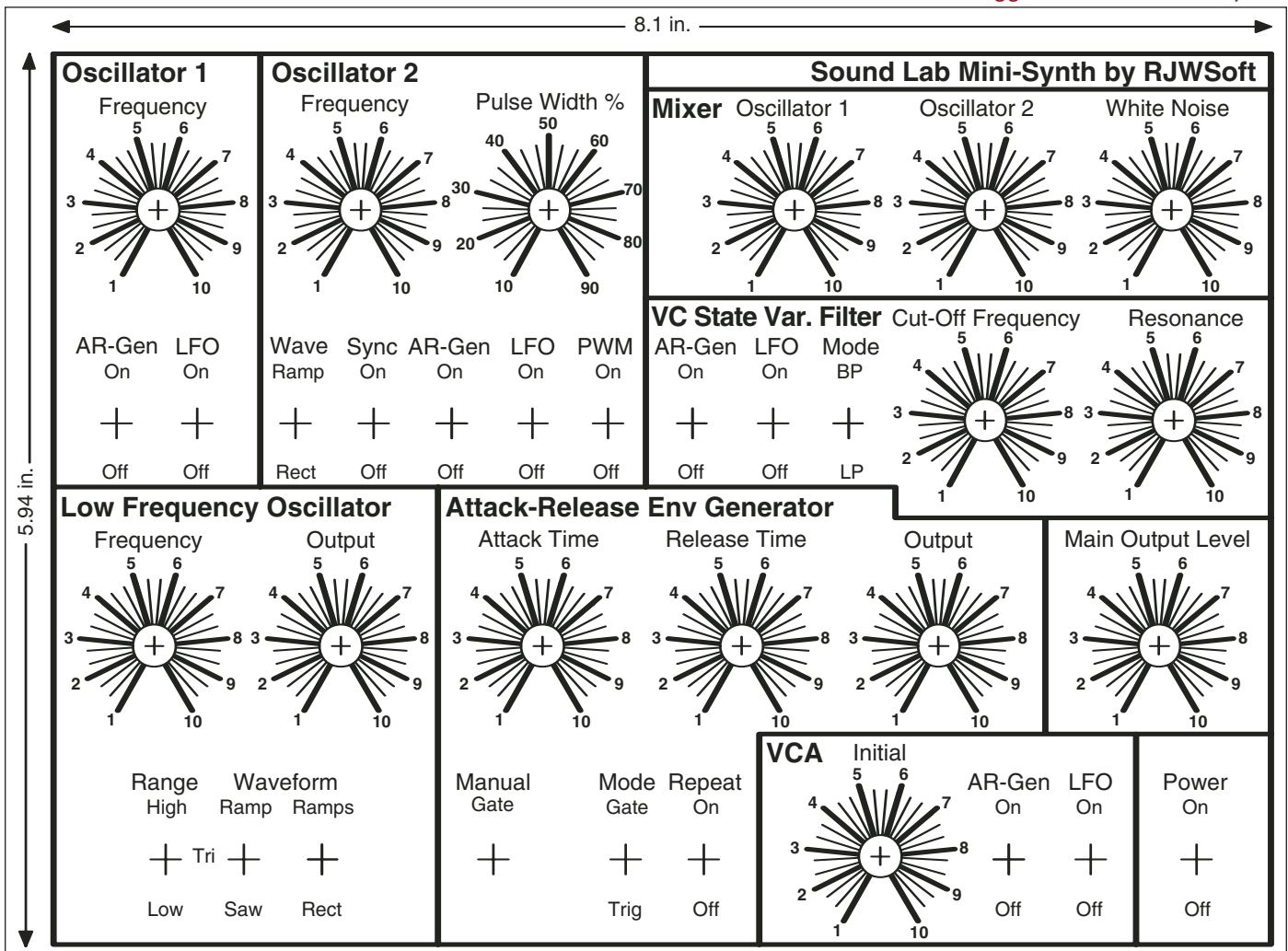
similar configuration.

The output of IC6-D (point ZZ) is fed into comparator IC2-A in order to provide a square/pulse wave shaper for Oscillator 2. The control voltage fed into IC2-A pin 2 via resistors R86 and R87 determines the comparator threshold and thus the point at which the output (pin 1) goes high and low.

Varying R85 will change the pulse width and vary the timbre of Oscillator 2 when Rect Wave is selected. S15 permits the LFO output voltage to modulate the pulse width, which can cause the output of Oscillator 2 to sound like two oscillators tuned very close together (when approximately 1 Hz LFO frequency is used).

S11, S13, S12, and S14 are used

■ **FIGURE 6. Sound Lab Mini-Synth Suggested Front Panel Layout.**





to feed the AR Generator and LFO outputs to the CV inputs of the VCOs. When on, you will hear the obvious effect as you advance the LFO and/or AR Gen output adjustments.

S9 causes Oscillator 2 to sync to the frequency of Oscillator 1. This provides some very cool timbres that you will hear if you turn on Sync and then tune Oscillator 1 lower than Oscillator 2 and sweep Oscillator 1 upward in frequency.

NOTE: If you don't plan to use the external CV (Control Voltage) capability of the device, you can eliminate the following components: R62 and R63.

■ **FIGURE 7. Sound Lab Mini-Synth Front Panel Wiring.**

Construction

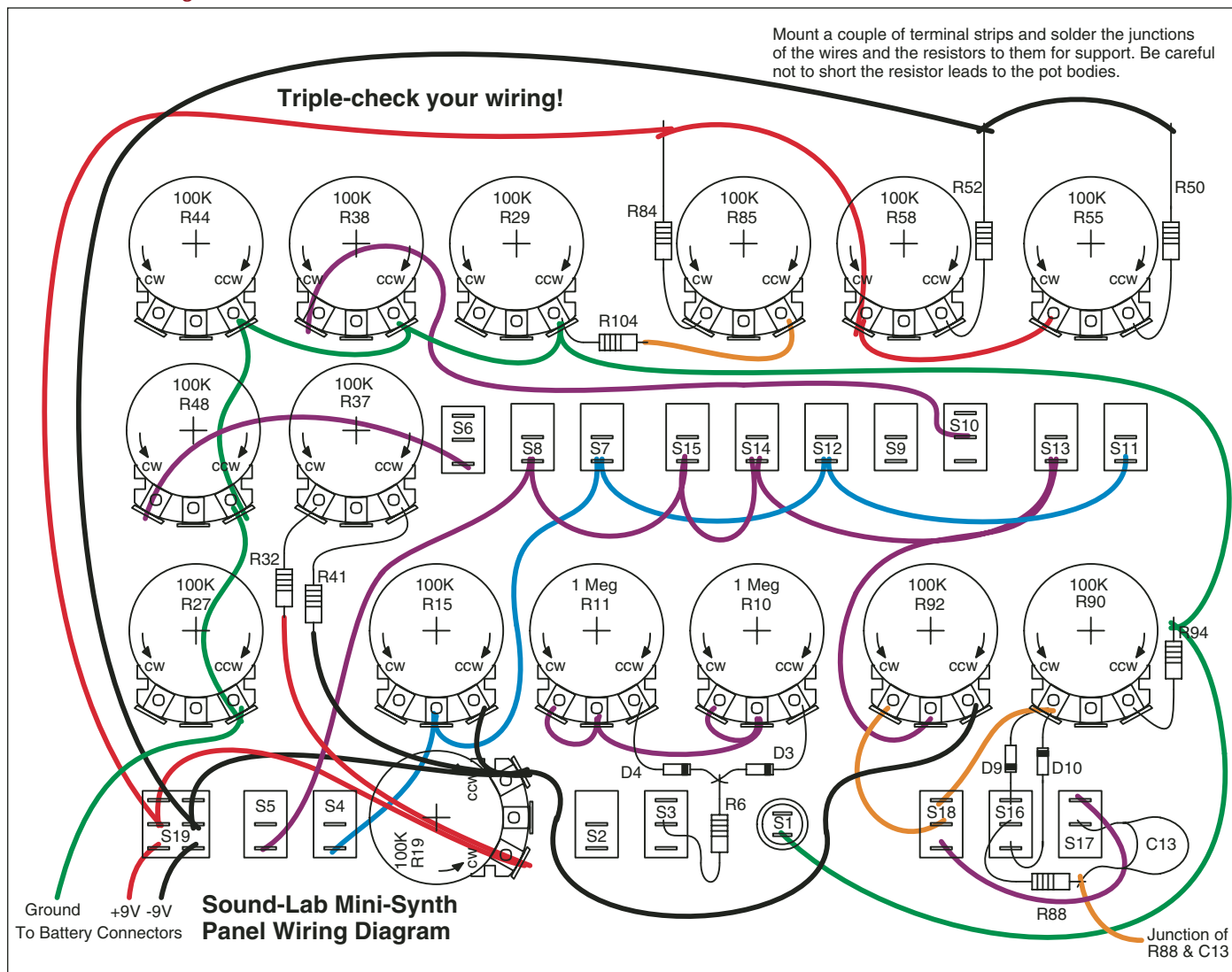
I highly suggest that you build the Sound Lab Mini-Synth on a PC board, but you can wire wrap it, breadboard it, or plain-old kludge it if you want to. Building the Sound Lab into an unusual case — perhaps involving some Plexiglas — can be an interesting project, but the front panel should be conductive (aluminum or steel). You can see the PC board layout and Parts legend for the Sound Lab Mini-Synth on the *Nuts & Volts* website (www.nutsvolts.com).

I can't stress enough how smart it is to use IC sockets. De-soldering ICs is never any fun and, as a matter of fact, it's a royal pain. If you ever have

to de-solder an IC, here is the correct method: First, cut all of the legs so that the body of the IC comes away from the board. Then, de-solder and remove each leg individually (unless you have one of those cool chip de-soldering tips for your soldering iron). Doing it this way — though tedious — will lessen the chance of PC board damage.

Front Panel

Once you decide on a case, drill all of the holes to accommodate the switches and pots that you bought. Figure 6 shows a useful layout, but feel free to be creative. Mount all of the switches and pots and then tighten the mounting nuts for every-



The Sound Lab Mini-Synth Sound Synthesizer

thing. If the case material is non-conductive, you will need to ensure that the potentiometer bodies are grounded in some manner. I highly recommend that the front panel be made of conductive material, as mentioned previously.

Wiring the Sound Lab

Use stranded copper wire (I suggest 22 to 24 AWG) to wire up the front panel (see Figure 7). You will notice that several components are mounted on the front panel. Use care in attaching them to one another and to the pots and switches as necessary, and make sure nothing is shorting to anything it is not supposed to be touching. Use shrink tubing and/or

terminal strips to insure good mechanical stability and electrical integrity.

As you wire the front panel, measure how long each wire needs to be as follows. With the wire still on the spool, unwind some and map out the path you want the wire to take. Leave yourself a little extra length for stripping and to insure that no wires are pulling on component terminals. When several wires are going to terminate at the same place, map all of those out and then solder them all to the common terminal together.

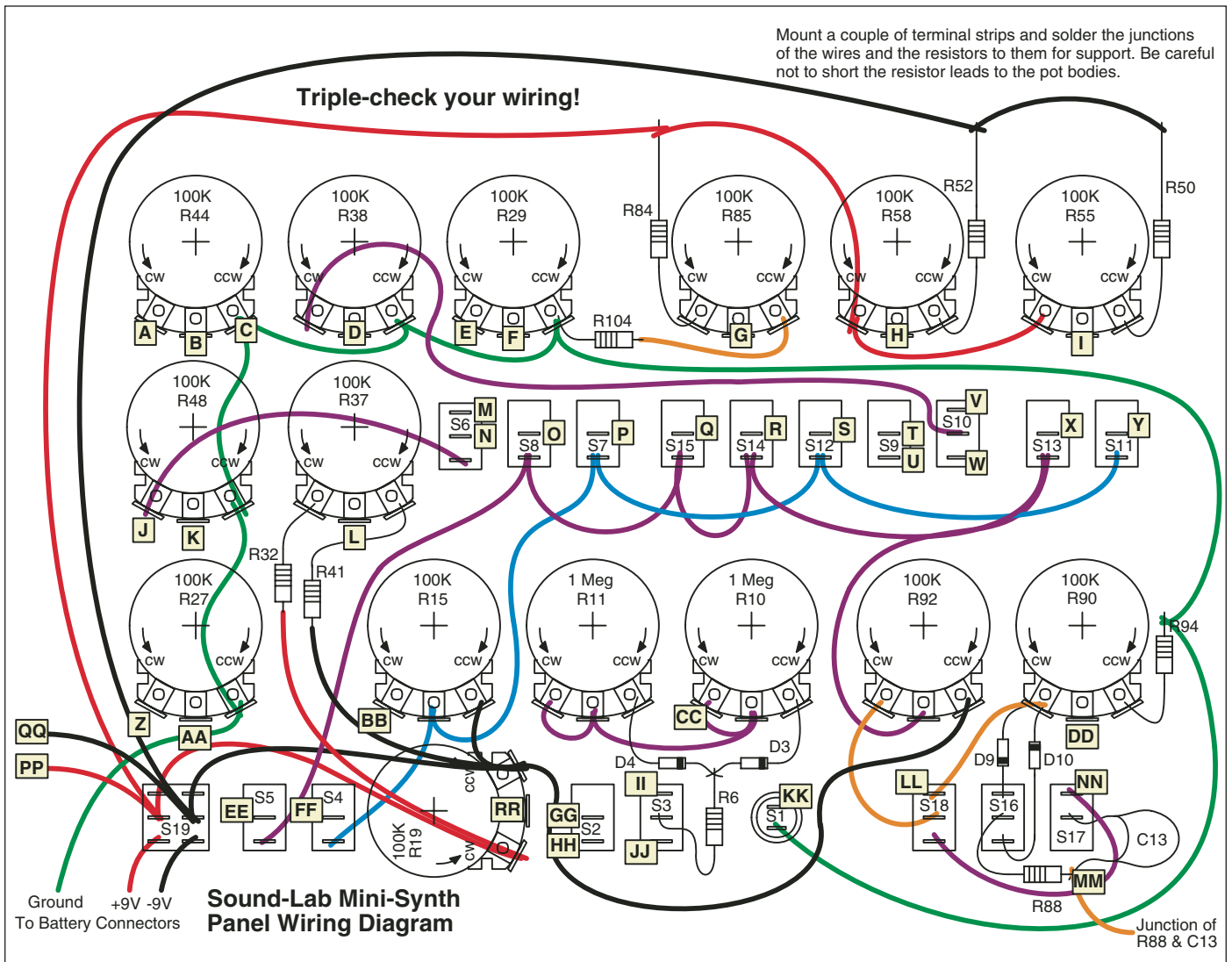
It's a good idea to run the wires from point-to-point first and dress them all neatly and then solder the discrete components to the

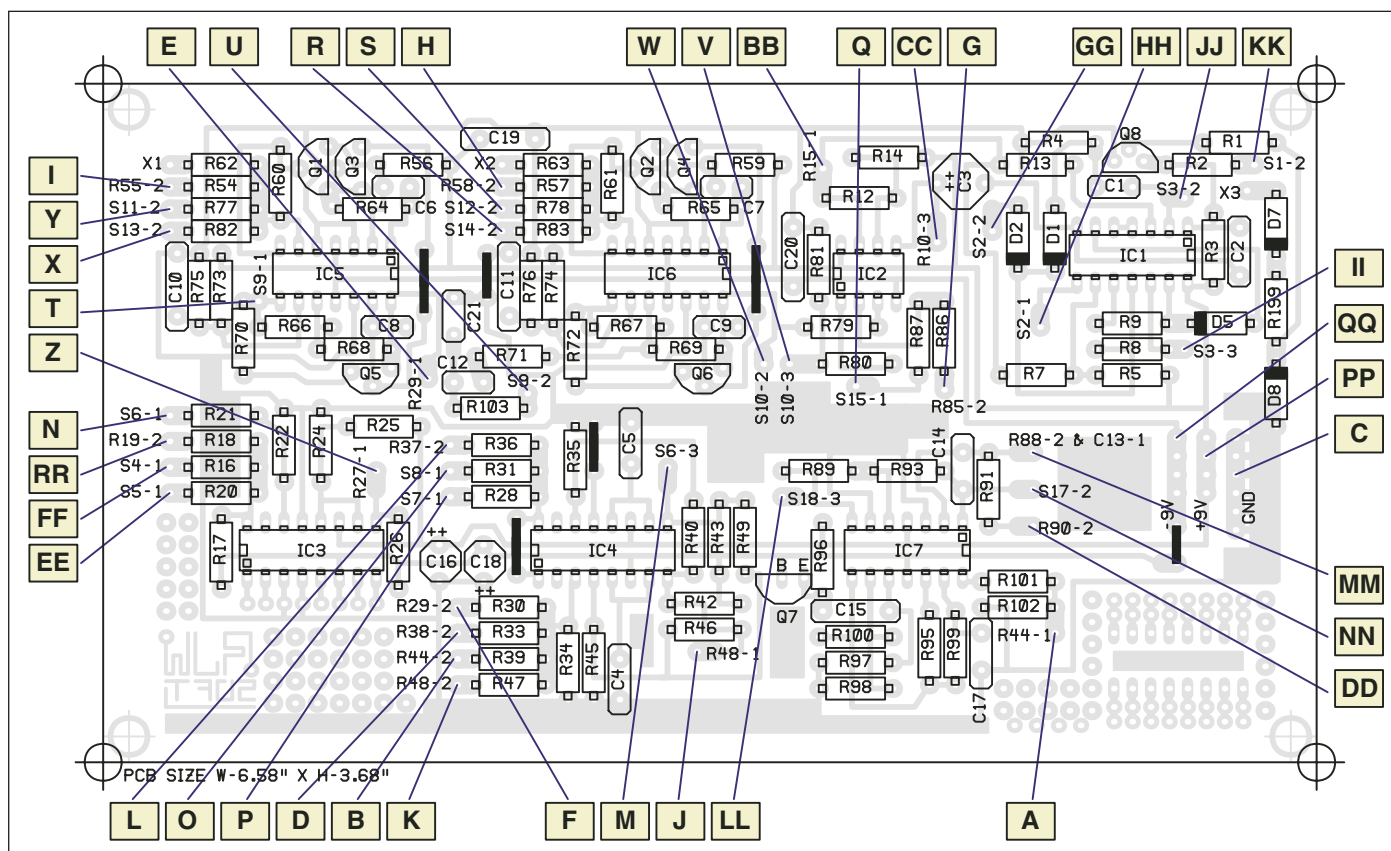
front panel component terminals. Neatness now pays big dividends when you are troubleshooting and/or modifying the unit later. Use several colors of wire to avoid visual confusion during troubleshooting and/or modification.

When populating a circuit board, I like to start with the IC sockets, then the jumpers, then the resistors, and finally, capacitors. Essentially, working from low parts to high parts will make the whole job easier. Put in about 10 components at a time, bending the leads to hold them in place.

Now, trim the leads and solder the components in place — keep

■ **FIGURE 8.** Sound Lab Mini-Synth Front Panel to PCB Labels.





■ **FIGURE 9. Sound Lab Mini-Synth PCB to Front Panel Labels.**

going until you are done. RadioShack sells a very nice "Nippy Cutter," which is excellent for trimming component leads. Remember to leave enough lead to solder to (about an 1/8 inch) and be sure that adjacent leads aren't shorted to one another.

When you are ready to connect the board to the front panel, it's a

good idea to do so in a manner that will let you fold (and unfold) the board under the front panel easily so that when you want to modify or troubleshoot the project, it will be far more convenient to do so. A little extra length on the wires from the panel to the board will translate into a lot less frustration later.

Figures 8 and 9 show the points that get connected together. Connect the labeled circuit point from the board to the

front panel point with the same label. Again, measure the wires and install them one at a time unless two wires go to the exact same point. I would suggest approaching the project in the following phases:

- Gather the components.
- Etch and drill the circuit board.
- Drill and label the front panel and make a case.
- Populate the circuit board.
- Populate the front panel.
- Wire the front panel to the circuit board.
- Go make some cool sounds.



■ **FIGURE 10. Sound Lab Mini-Synth Front Panel.**

ABOUT THE AUTHOR

■ **Ray Wilson** lives and works in Parker, CO. He is an avid electronics hobbyist who started his career in the medical electronics world. Today, when he is not updating his analog synthesizer website, building some new synthesizer module, or playing his guitar, he is managing a group of 20 software engineers in Englewood, CO. This is his first contribution to Nuts & Volts Magazine. His website is at www.musicfromouterspace.com

Testing the Sound Lab

Everyone who builds an electronic project spends a bit of time getting everything working. A missed solder joint here, a component with an incorrect value there, and all of a sudden things don't work. Here is some information to help you get everything going.

The first thing to do if you are having a problem is to remove the batteries (test and make sure they're good) and then look over all of the components on the circuit board. Are they all there? Are they all soldered in place? It is easy to overlook soldering a lead.

Next, review the panel wiring. Are all of the wires there? Are they all soldered to the correct place? Then, look over the wiring from the front panel to the PC board. Are they all there and, again, are they all soldered from and to the correct place?

I have built and tested the Sound Lab and I am certain that if it is wired correctly, it will definitely work. If you are still having a problem and you are certain that the construction is complete, try substituting known good ICs for the ones on the board (I hope you used sockets). If you are still having a problem, re-read the circuit descriptions and probe the circuit using a signal tracer, oscilloscope, and/or DVM to make sure that it is functioning as described. **NV**

PARTS LIST

| QTY | DESCRIPTION | VALUE | SCHEMATIC DESIGNATOR OR ADD'L INFO |
|-----------------------------|--------------------------|------------|---|
| | | | RadioShack Part# 270-325 |
| <input type="checkbox"/> 2 | 9V Battery Connectors | | |
| <input type="checkbox"/> 2 | 9V Batteries | 9 Volt | |
| <input type="checkbox"/> 1 | CD40106 Hex Inverter | CD40106 | IC1 |
| <input type="checkbox"/> 1 | Ceramic Capacitor | 0.001μF | C1 |
| <input type="checkbox"/> 1 | Ceramic Capacitor | 0.005μF | C14 |
| <input type="checkbox"/> 2 | Ceramic Capacitor | 0.01μF | C2, C12 |
| <input type="checkbox"/> 2 | Ceramic Capacitor | 0.02μF | C8, C9 |
| <input type="checkbox"/> 5 | Ceramic Capacitor | 0.1μF | C10, C11, C15, C19, C20 |
| <input type="checkbox"/> 2 | Ceramic Capacitor | 100pF | C6, C7 |
| <input type="checkbox"/> 1 | Ceramic Capacitor | 1μF NPO | C22 |
| <input type="checkbox"/> 1 | Ceramic Capacitor | 2μF | C13 |
| <input type="checkbox"/> 2 | Ceramic Capacitor | 330pF | C21, C17 |
| <input type="checkbox"/> 2 | Ceramic Capacitor | 560pF | C5, C4 |
| <input type="checkbox"/> 1 | DPST Switch | DPST | S19 |
| <input type="checkbox"/> 2 | Electrolytic Capacitor | 100μF | C16, C18 |
| <input type="checkbox"/> 1 | Electrolytic Capacitor | 2μF | C3 |
| <input type="checkbox"/> 1 | LF442 Dual op-amp | LF442 | IC2 |
| <input type="checkbox"/> 3 | LF444 Quad op-amp | LF444 | IC5-IC7 |
| <input type="checkbox"/> 2 | LM13700 op-amp | LM13700 | IC3, IC4 |
| <input type="checkbox"/> 2 | MPF102 N-Channel JFET | MPF102 | Q5, Q6 |
| <input type="checkbox"/> 1 | Phone Jack | 1/4" Jack | J1 |
| <input type="checkbox"/> 13 | Potentiometer | 100K | R15, R19, R27, R29, R37, R38, R44, R48, R55, R58, R85, R90, R92 |
| <input type="checkbox"/> 2 | Potentiometer(s) | 1M | R10, R11 |
| <input type="checkbox"/> 2 | Resistor 1/4 watt 5% | 2K | R61, R60 |
| <input type="checkbox"/> 4 | Resistor 1/4 watt 5% | 1 Meg | R56, R59, R66, R67 |
| <input type="checkbox"/> 17 | Resistor 1/4 watt 5% | 100K | R1, R4, R12, R14, R24, R36, R54, R57, R62, R63, R68, R69, R73, R74, R79, R86, R93 |
| <input type="checkbox"/> 9 | Resistor 1/4 watt 5% | 10K | R26, R32, R50, R52, R64, R65, R102, R103, R199 |
| <input type="checkbox"/> 4 | Resistor 1/4 watt 5% | 150K | R17, R30, R33, R39 |
| <input type="checkbox"/> 7 | Resistor 1/4 watt 5% | 1K | R22, R23, R34, R35, R45, R88, R98 |
| <input type="checkbox"/> 9 | Resistor 1/4 watt 5% | 1M | R2, R8, R9, R87, R99, R95-R97, R91 |
| <input type="checkbox"/> 4 | Resistor 1/4 watt 5% | 200K | R28, R31, R84, R89 |
| <input type="checkbox"/> 8 | Resistor 1/4 watt 5% | 20K | R40, R42, R43, R46, R47, R70, R72, R80 |
| <input type="checkbox"/> 4 | Resistor 1/4 watt 5% | 220K | R77, R78, R82, R83 |
| <input type="checkbox"/> 2 | Resistor 1/4 watt 5% | 2M | R5, R13 |
| <input type="checkbox"/> 1 | Resistor 1/4 watt 5% | 33K | R21 |
| <input type="checkbox"/> 1 | Resistor 1/4 watt 5% | 3M | R7 |
| <input type="checkbox"/> 2 | Resistor 1/4 watt 5% | 4.7K | R41, R81 |
| <input type="checkbox"/> 2 | Resistor 1/4 watt 5% | 4.7M | R3, R100 |
| <input type="checkbox"/> 4 | Resistor 1/4 watt 5% | 470K | R16, R18, R20, R71 |
| <input type="checkbox"/> 5 | Resistor 1/4 watt 5% | 47K | R49, R75, R76, R104, R101 |
| <input type="checkbox"/> 2 | Resistor 1/4 watt 5% | 500Ω | R6, R94 |
| <input type="checkbox"/> 1 | Resistor 1/4 watt 5% | 620K | R25 |
| <input type="checkbox"/> 1 | SPDT Switch (center off) | SPDT | S16 |
| <input type="checkbox"/> 4 | SPDT Switch | SPDT | S3, S6, S10, S18 |
| <input type="checkbox"/> 1 | SPST Push Button | SPST | S1 |
| <input type="checkbox"/> 12 | SPST Switch | SPST | S2, S4, S5, S7, S8, S11-S13 |
| <input type="checkbox"/> 8 | Silicon Diode | 1N914 | S14, S9, S15, S17 |
| <input type="checkbox"/> 1 | Silicon Zener Diode | 9.1V Zener | D1-D5, D7, D9, D10 |
| <input type="checkbox"/> 6 | NPN Transistor | 2N3904 | D8 |
| | | | Q1-Q4, Q7, Q8 |

ADDITIONAL MISCELLANEOUS PARTS REQUIRED

- ☐ 1 1/16" thick aluminum plate 9" x 7" for mounting the pots and switches.
- ☐ One case to hold the unit (homemade wooden box, aluminum project box, etc.).
- ☐ Assorted hardware: 1" 6-32 nuts and bolts, 1/2" #8 wood screws, etc.
- ☐ Wire, solder, and typical assorted electronics hand-tools.
- ☐ DVM (Digital Volt Meter) and a signal-tracer or oscilloscope for testing

NOTES

- ☐ You can substitute a TL084 and TL082 in place of LF444 and LF442, respectively; but they draw quite a bit more current, which will decrease battery life.
- ☐ You can substitute an LM13600 in place of the LM13700.
- ☐ You can substitute a 1N4148 for a 1N914.

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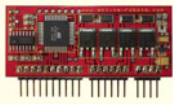
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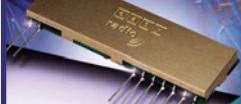
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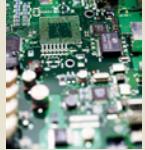
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I have Type 2 Diabetes and have to exercise on a regular basis to keep my blood sugar under control.

One form of low impact exercise is an exercise bike, however, as with any exercise, we are more likely to do it on a regular basis if we can stay motivated.

As a software and hardware developer, I decided to create an interface to one of my exercise bikes. Before I started, I set out with a few requirements.

■ **The interface had to work with any bike.**

■ **The interface had to work with a Desktop PC, Laptop, or Pocket PC.**

■ **The cost of the interface had to be very cheap and use a minimal amount of components.**

GET MOTIVATED

After a bit of experimenting, I think I have a great start towards a really cool interface that will work with any bike.

Interface

I thought to myself: What is the best way to interface to a PC?

Well, every PC and laptop has USB. The downside is that the interface can be expensive and pocket PCs don't have a USB interface that's accessible.

Printer ports are out because they are increasingly being replaced by USB. I could use IRDA, but again, the interface circuitry would be too complicated.

What about serial? Most of the newer laptops don't have serial ports anymore. Even the laptop I'm using to write this article does not have one. However, you can pick up a USB-to-Serial converter for under

\$25 at Walmart.

I decided to try the serial port route.

One of my first questions was how to detect the peddle movement on the exercise bike. Easy! I decided to use a Hall-effect sensor. These can be purchased at several online stores for a few dollars.

There are several Hall-effect sensors available. We will be using a 6853 chip that runs off of 5V and has a normally low signal on its output lead (pin 3). When a magnetic field is detected, it floats the lead so you can pull it high with a 1K resistor. Some Hall-effect sensors will latch and need to be released. This type will not work for this project.

By connecting the output lead to the receive pin of a serial interface, the PC will read a 0 each time the sensor sees a magnetic field. The neat thing is that the result will be the same at just about any baud rate. Why does this work?

The idle state of an RS232 signal is -12 volts. This is the low state. When the start bit occurs, it goes from the low (idle) state to high. Sound familiar? This is what happens when our sensor detects a magnetic field. Well, kind of. In reality, we go from a 0 level to a +5V. This will work on 90% of the newer devices as they are very forgiving. They see anything less than .5V as a low and above 3V as a high. I tested it on every device I had in my lab, which



■ FIGURE 1

consists of 12 desktop PCs, three laptops, four pocket PCs, and various serial converters of one type or another.

The Basic Circuit

Take a look at Figure 2. This is how you would connect to a desktop PC or laptop. Pocket PCs are considered DTE devices, so you will need a male connector and will have to connect the sensor output to pin 2 of the DB9 connector.

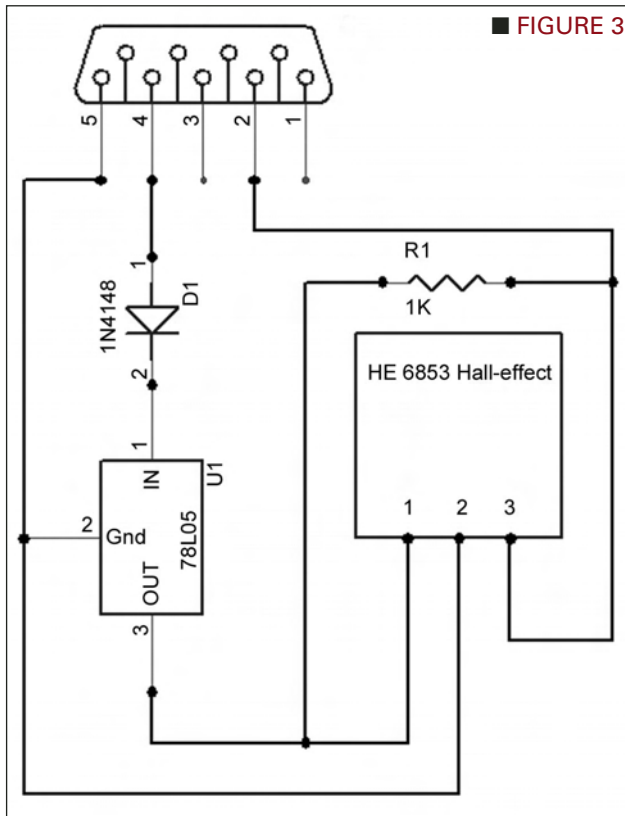
Don't rush out and build this circuit because we are going to do it one better.

I don't want to have to use a battery or AC adapter, so I decided to power the interface. By adding a 78L05 and a diode, you can create a self-powered version, as shown in Figure 3.

We are using pin 4, DTR to power the circuit. First, we run it through a diode so we don't blow anything up if the DTR is set low. When low, the cathode side of the diode will float, effectively turning off the circuit. Once DTR is raised, the positive voltage will drive the 78L05 and get regulated down to 5V. You don't need much since the whole circuit only pulls a few milliamps.

Sensor Hookup

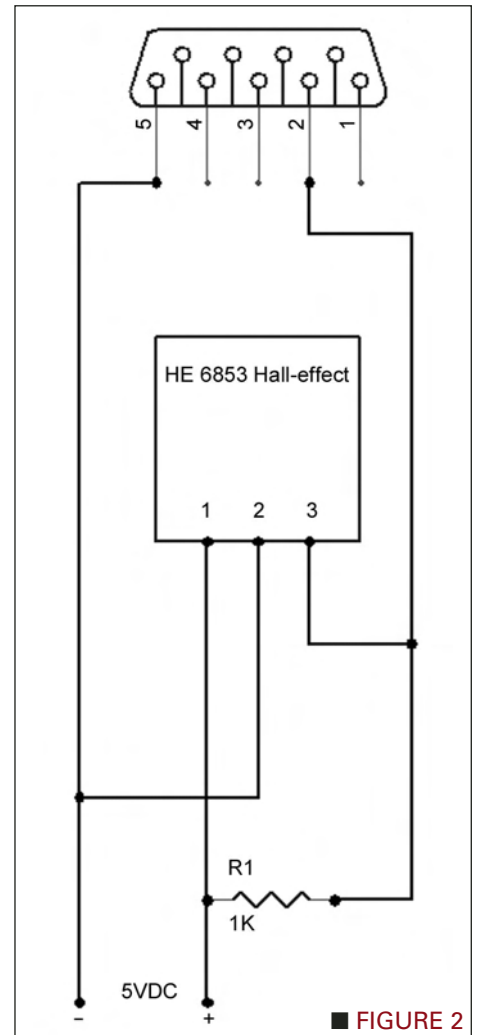
How you connect the sensor depends upon your bike. All bikes have some sort of rotating part that the peddles are connected to. The bike I have has an onboard computer so it already has a sensor. Figure 4 shows how I just hot glued my sensor to the top of the existing sensor.



■ FIGURE 3

It already has a magnet mounted on the main drive so I simply oriented my sensor so that the front of the sensor faced the magnet, as shown in Figure 5.

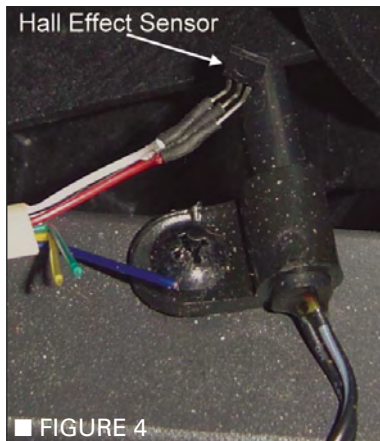
I strapped the cable down with tie wraps to help secure the sensor. If your bike does not already have a magnet, you will need to hot-glue one to the drive mechanism somewhere. Keep in mind that if you don't want to open up your bike, it is possible to



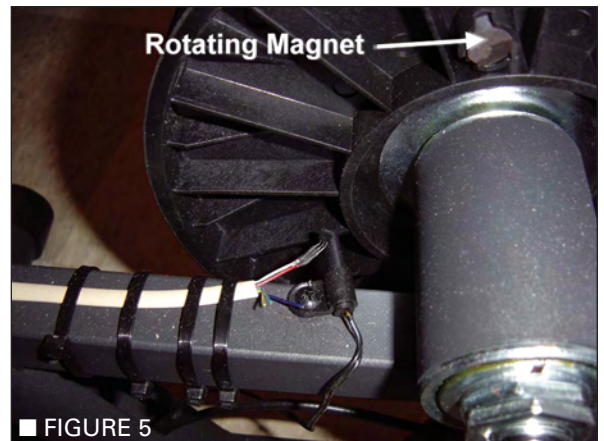
■ FIGURE 2

mount the sensor on the exterior of the bike and a magnet on one of the peddle arms. This is what I plan on doing to one of my other bikes.

That's it on the interface. It will



■ FIGURE 4



■ FIGURE 5



cost you around \$5 for the parts, depending on what you have in your junk box. As far as assembly goes, I soldered the 78L05, diode, and resistor directly to the connector.

Software

Now, for the fun part. We will use a development program called Zeus. There is even a special *free Nuts & Volts* version up on the *Nuts & Volts* website (www.nutsvolts.com). Let's see how this will work.

Sensor Test

I'm going to start with a simple program just to test if the sensor is working properly.

Program 1 is fairly straightforward. We open up the com port. If the ComOpen returns a 0, we have an error so we display an error message and exit the program.

Once we have an open port, we raise DTR with the ComDTR command. This provides power to the interface.

We then run a very tight loop that checks the status of the com buffer with the ComBuff command. If it returns anything greater than 0, we know we have a sensor event.

We increment the Rot variable

then print the received value, as well as the Rot value.

Note that you have to access the ComInput command to pull the data out of the buffer or the ComBuff command will just keep getting larger and won't ever return a 0.

Race Program 1

I'm not going to list the Race Program 1 here because it can be found on the *Nuts & Volts* website, as well as the Kronos Robotics website. I will, however, walk you through each section of the code.

There are four functions used to make up Race Program 1.

- *initBike(ComPort)*

This function opens the indicated port and sets DTR to power the interface.

- *DrawTrack()*

This function draws the track. You can change the FormBrush values to change the track colors.

- *PlotPlayers(Player, Rotations)*

This function plots a player pip at a particular position on the track based on its Rotation value. Note that player 1 is the sensor and players 2-4 are the bot players.

- *Main()*

This is the entry point of the program. This is where most of the work gets done and, due to its complexity, it is broken down into its own sub sections.

Main Setup

Here we set up the program by creating a few arrays.

| | |
|------|---|
| Tots | Total of all rotations (sensor events). |
| Rots | Current rotations of current lap. |
| Pos | Race position. |

First, Second, Third, and Fourth.

Laps Completed laps.

A call to initBike is also made. Notice that I am using com port 4. You will need to pass the com port number your interface is connected to.

Main Loop

Here we set a variable called ticks. This variable will increment every 10 milliseconds. Once we get a tick value greater than 3, we reset the counter and using a random number generator, increment the position of each of the bot pips. For instance, take the following snippet of code:

```
if Random(1,10) > 4 then
    rots(2) = rots(2) + 1
endif
```

Here, a random number between 1 and 10 is generated. If it is greater than 4, we will increment the bots rotation count. This equates to a 40% chance of this particular pip advancing one position every 40 ms.

By changing the value from 4 to 8, you effectively double the skill level of this bot. This would give the appearance of that bot running faster on average.

After the rotations are calculated, we then draw the track and plot all four player pips.

Main Calculate Position

Here, we do a quick bubble sort to calculate each players position in the race.

Main Display Lap Data

Here, we display the text data indicating the player name, his position, and number of laps completed.

Main Check Com Buffer

Here, we check for activity on the com buffer. If we have activity, we increment the (player 1) rotation counter.

Going Further

I consider this a starting point as

Program 1. Sensor Test

```
'Exercise Bike Sensor Test
func main()

    gconst chBike 1
    dim Rot as integer
    clearall

    if ComOpen(chBike,baud=9600,port = 4) = 0 then
        MsgBox("Error Opening Com Port")
    end
    endif

    'Power up the connector
    ComDTR chBike,1

Loop:
    if ComBuff(chBike) > 0 then
        Rot = Rot + 1
        Print val(ComInput(chBike)), "Count="+Rot
    endif

    DoEvents
    goto Loop

endfunc
```


there are plenty of enhancements you can make to the program. Here are a few ideas.

- You could keep track of lap times using the Getms command and creating a LapTime Array.
- You could calculate other data points like speed, calories, and distance. If you have a computer on your bike, this will be easy as you have something to help you calibrate your calculations.
- You could keep track of all your laps so that you could replay them as one of the bot players to race against your own times.
- You could dynamically change the skill levels of the bots, thus simulating the fact that players will start to slow down as they get tired.
- You could add sound effects or voice commands to your program using the PlaySound command.
- You could upgrade to ZeusPro and add bitmaps and double buffering for smoother graphics.
- Add missiles so you can blow up any of the bot pips that get in your way.

PARTS LIST

None of the parts are critical; for instance, any diode will work. You will need a DB9 female if you are connecting to a PC or laptop and a DB9 male if connecting to a pocket PC. Other Hall-effect sensors will work. Just make sure you use the non-latching type.

| | |
|--|--|
| <input type="checkbox"/> 78L05 Regulator | Kronos Robotics #16207 |
| <input type="checkbox"/> 6853 Sensor | Kronos Robotics #16211 |
| <input type="checkbox"/> 1K Resistor | Kronos Robotics #16178 |
| <input type="checkbox"/> 1N4148 Diode | Kronos Robotics #16135 |
| <input type="checkbox"/> DB9 Male | Kronos Robotics #16254 |
| <input type="checkbox"/> ZeusNV | Nuts & Volts website |
| <input type="checkbox"/> ZeusPro | KRMicros website under development section |

Final Thoughts

If you plan on building a pocket PC version of this software, I recommend building and testing it first with a PC or laptop. You can always use a null adapter to connect to the pocket PC if you build the circuit to interface to the PC.

Feel free to experiment with the code to create the ultimate motivator. Contact me in care of the KronosRobotics website and I will post your code up on the website. You can also post your code up on the forums listed in the Web Links sidebar.

I successfully used a Bluetooth-to-RS232 adapter to connect my pocket PC without a cable. This type

of converter is a valuable one to add to your workbench. I keep one in my laptop bag, as well.

Be sure to visit both the KronosRobotics and KRMicros website for other versions of the bike interface code. **NV**

WEB LINKS

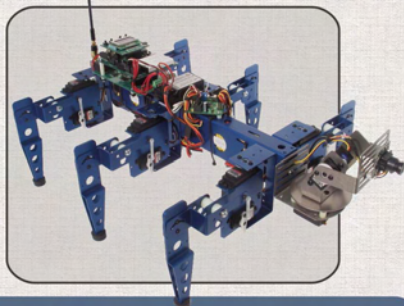
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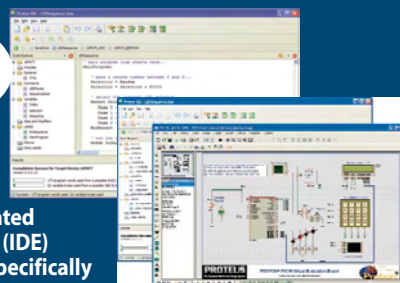
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In a bit of corporate euthanasia, Sony Corporation has announced the cancellation of its four-legged robotic pet program — Aibo. As part of a major restructuring plan aimed at thwarting its waning fiscal fortunes, Sony will formerly cease production of this lovable, albeit costly, robot dog in March 2006.

What about those approximately 150,000 owners of this dog? What will they do if their pet needs to see a vet? In the same breath announcing the death of the \$2,000 Aibo, Sony also promised to extend its maintenance (both parts and service) program for an additional seven years.

Most of the current Aibo owners interviewed in a CNN.com news report ("Sony Puts Robot Dog to

Sleep," February 2, 2006) weren't convinced about the sincerity of Sony's maintenance extension. Feeling that this gesture was more of a marketing dog bone than a genuine doggie treat, these jaded owners thought that Sony should be relegated to the global electronic dog pile and not their beloved puppy pal. But Sony isn't about to play dead.

Attempting to roll over from its current financial woes, Sony will concentrate on its core electronics business and its massive entertainment arm. Although still reeling from a recent marketing fiasco over its brutish music copy-protection enforcement scheme, Sony is hoping to fetch a brighter bottom line when their revolutionary PlayStation® 3 video game console is released.

STUDENT-BUILT BUOY LAUNCHES OCEAN STUDIES

Over the holidays, high-school sophomore Katie Nance painted her room a cool shade of blue. But she and her schoolmates chose something much bolder for the ocean buoy they recently constructed for an international oceanography program. Their bright red buoy is being launched off the coast of Antarctica. If all goes well, the buoy will phone home, thanks to a satellite connection, sending back data on ocean temperatures that will be available to scientists and students around the world.

The buoy project is part of an education program called Argonautica organized by the French space agency, the Centre National d'Etudes Spatiales. With help from JPL, a small group of students from a local French/American school, the Lycee International de Los Angeles, has become the first US participant. The roughly dozen team members were drawn from different classes, ranging in age from 9 to 17. Dr. Mohamed Abid, a senior systems engineer for NASA's Ocean Surface Topography Mission, served as their advisor.

Argonautica is designed to help students learn about the oceans and

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includes a prototyping area so the user can add external circuitry. There is an onboard voltage regulator for powering the Micro64/128 and additional circuitry. The Micro64/64A/128/128A development system comes complete with a Micro64, Micro64A, Micro128 or Micro128A, a Micro64/128 Development Board, and a power supply.

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the role of satellites in oceanography. Participants are given an empty plastic shell from which they have to construct a functional buoy fitted with sensors capable of withstanding harsh ocean conditions, plus an anchor to keep the buoy in position as it drifts with the currents.

The first challenge, says seventh grader Turner Edwards, "was figuring out what we wanted to measure. Some wanted to measure the salt in the water, some temperature, and some currents. It was hard to decide."

They had expert help. Abid is the author of a new book titled *Spacecraft Sensors*. "We had a number of options," he says, "so we made lists of the pros and cons of our different choices. We finally chose the temperature sensor." The next steps were to understand how the sensors work, test them, and make sure they will survive in salt water.

For Nance, the hardest part of the project was all the calculations that needed to be done. "We had to figure out where we were going to put the sensors, how much weight needed to be in the anchor, how many volts we needed for the Argos card — the satellite transmitter."

Last December after more than a year of work, the Argonautica team completed their buoy with seven temperature sensors and an anchor, which they constructed from plastic pipe and cement. The final step was the red paint. "It looked really good," says Nance, "but there's not much you can do with a buoy."

Isabelle Autissier, a well-known French sailor, is launching the buoy from her ship Ada2. She is on an expedition to retrace the routes of some early Antarctic explorers, including Jean-Baptiste Charcot and Ernest Shackleton. Students will be able to track their buoy and other Argonautica-built buoys from the French space agency's education website and correlate the data they collect with measurements of sea surface height made by the Jason satellite, a joint US/French mission.

"This was so much fun to build and put together," says Nance. "We were so

proud of ourselves. The best part was working as a team." Edwards agrees, "It was really fun to collaborate. It was nice to come from nothing and do a project from start to finish."

"It's great to see what they can accomplish," says Abid. "Now that they can see what they can do, their expectations get higher. They believe that next time they can build something even more complex."

In France, about 60 school groups participate in Argonautica each year, and the program is expanding in Europe. "We think it is a great program and wanted to bring it to the States," says Annie Richardson, who coordinated the effort in Los Angeles. Richardson is an outreach coordinator at JPL for the Jason mission and the upcoming Ocean Surface Topography Mission. "Many of the

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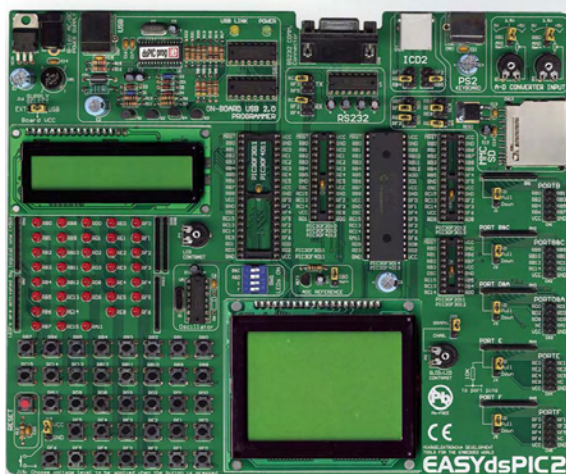
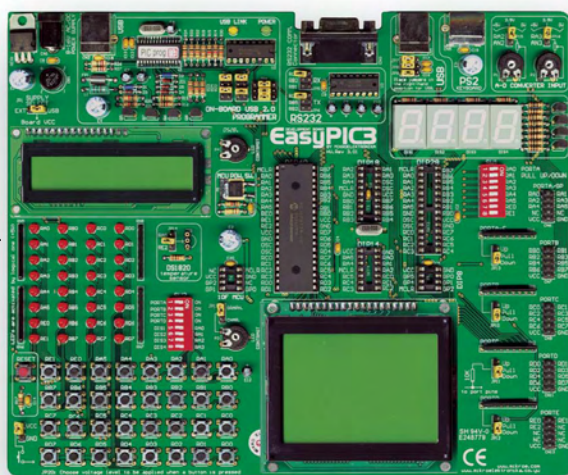
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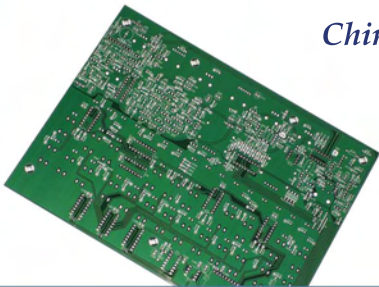
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Argonautica materials are in French, so we started our pilot project with a small group of students who speak French, but we hope to expand the program to include more schools. We're also developing a pilot Argonautica program for the Boys and Girls Club."

More information about Argonautica can be found at www.cnes.fr/html/_98_3112_3147_.php More information about ocean surface topography is available at <http://sealevel.jpl.nasa.gov>

MICROCHIP BROADCASTS FROM SPACE

Microchip is playing a special role in the release of an unusual earth-orbiting satellite.

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recorded message and various data about its mission over ham radio frequencies. The message and broadcast are controlled by three boards integrated by Microchip.

Microchip built the controller board using a PICC microcontroller unit and a switchbox board. The company then integrated those two with the translator box, according to Steven Bible, an applications engineer at Microchip and a ham radio enthusiast.

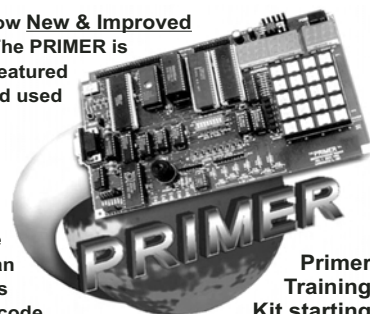
The devices will play back recorded greetings from children in several languages and also the suit's temperature, battery voltage, and the mission's elapsed time in a nine-minute sequence that will be repeated over and over. The message will be broadcast at ham radio frequencies so classrooms around the world can listen to it, Bible said.

"The purpose of the mission is mainly educational," he said, adding that the organization in charge of including the radio was ARISS or the Amateur Radio on International Space Station. The chairman of that organization is Frank Bauer, a NASA engineer. Bible was personally contacted by a friend and asked if he and his company could participate.

"What this organization does is plan ham radio activities from the International Space Station," said Bible. "There is a ham radio station on board. Astronauts use it to talk to schools around the world. They do this once a week." **NV**

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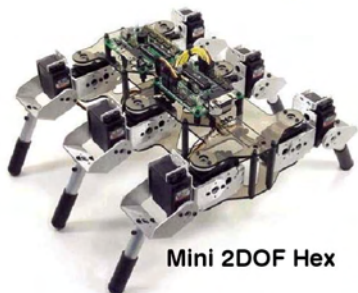
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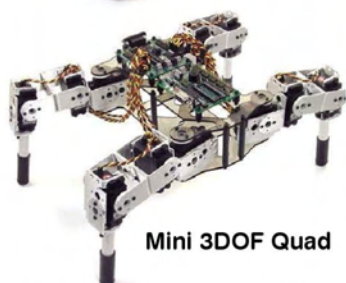
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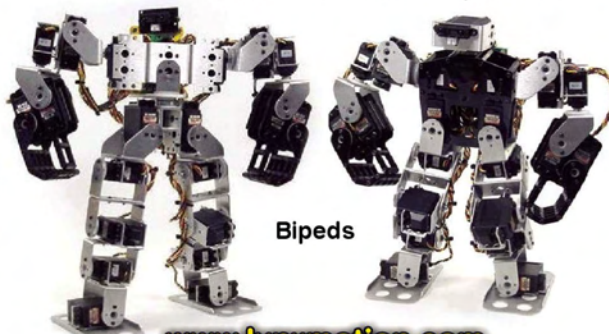
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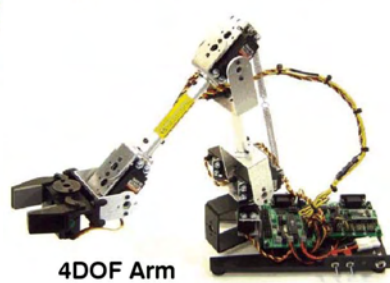
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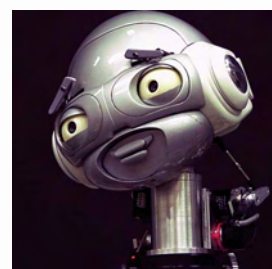
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LEAVING THE CRADLE



Colorful Entrepreneurs Fund Commercial Manned Spaceflight

by Edward Driscoll, Jr.

In 1911, Russian space pioneer Konstantin Tsiolkovsky famously wrote, "The Earth is the cradle of humanity, but mankind cannot stay in the cradle forever."

NASA's early space program culminating in the 1969 landing on the moon was something of a false start — much was accomplished, and then essentially abandoned for budgetary reasons. The Space Shuttle today seems both a limited and dated technology, and NASA's current resources leave little room for expansion. But if Burt Rutan, Paul Allen, and Richard Branson have their way, private industry will be taking its own first baby steps in helping mankind leave the cradle.

Rutan is the veteran aviation

designer who won the \$10 million Ansari X Prize in 2004, which called for a reusable manned spacecraft to fly to the edge of space (100 kilometers/62 miles) twice within two weeks. His SpaceShipOne design fulfilled those requirements by flying on September 29th and October 4th of 2004, with a pilot and approximately 400 pounds of weight to simulate the weight of two crewmen. Paul Allen of Microsoft personally funded Rutan's Scaled Composites (www.scaled.com) — the company that built SpaceShipOne and owns the technology behind it.

The flamboyant Branson created Virgin Galactic (www.virgingalactic.com) to put that technology to

Refer to the photos above:

PHOTO A. SpaceShipOne in feather mode prepares for re-entry from space. Video capture courtesy of Vulcan Productions/Discovery Channel.

PHOTO B. SpaceShipOne is shown gliding back to base during flight 15P in an air-to-air photograph. Photo courtesy of Jim Campbell/Aero-News Network.

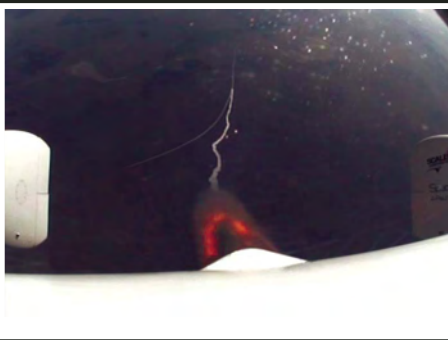
PHOTO C. SpaceShipOne sits on the ramp on its landing gear.

PHOTO D. Shown just before touchdown at 90 mph, SpaceShipOne returns to the runway.

PHOTO E. SpaceShipOne lands in front of a crowd of 27,500 people after its first flight to space. Photo courtesy of Jim Campbell/Aero-News Network.



SpaceShipOne ignites its engine after being released by the White Knight mothership. Video capture courtesy of Vulcan Productions/Discovery Channel.



SpaceShipOne shoots away from the White Knight and into space. Video capture courtesy of Vulcan Productions/Discovery Channel.



SpaceShipOne underneath the White Knight at 45,000 feet. Video capture courtesy of Vulcan Productions/Discovery Channel.

commercial use. In July 2005, the two businesses announced in a press release their intent to form "The Spaceship Company (TSC), a new aerospace production company which will build commercial manned suborbital spaceships and launch aircraft. Scaled Composites has agreed to develop the new systems and to provide TSC with the technology required to allow them to produce the flight vehicles, as well as to support the spaceline operators."

In an attempt to support the efforts of Virgin and Scaled, the state of New Mexico announced plans to construct a purpose-built commercial spaceport — one of seven current or

planned facilities in the US. The New Mexico site will house Virgin Galactic's world headquarters and mission control for its personal spaceflight business. The spaceport will be built on a 27 square mile site in Upham, about 30 miles east of Truth or Consequences.

By 2008, Virgin Galactic plans daily commercial spaceflights, increasing to three seven-passenger spaceflights per day from that facility. Virgin currently estimates that they'll launch 50,000 passengers into space during their first 10 years of operation. Current seat prices are \$200,000 a pop, but just as airline seat prices have fallen dramatically in the last 30 years ("You are now

free to move about the country ..."), Virgin expects these ticket prices to drop, as well.

Entrepreneurs Want to Make Sci-Fi a Reality

Why are entrepreneurs such as Branson, Paul Allen, and Jeff Bezos of **Amazon.com** becoming increasingly involved in funding private spaceflight ventures? In addition to a growing number of technology advancements that make such efforts progressively more feasible, there's also a cultural component. Glenn Reynolds of **Instapundit.com** is the author of *An Army of Davids* (published by Nelson Current), a 2006 book on empowering technologies, with a chapter titled "Space: It's Not Just For Government, Anymore." Reynolds says, "You now have a generation of rich guys who, like me, grew up on science fiction, and really want to make this stuff a reality. I think it's kind of like what you saw in the 1920s and 1930s, when you had a lot of relatively young rich guys who were investing, and sometimes even participating, in the pursuit of these various aviation prizes (Howard Hughes being the most famous example, but there were actually a lot of them.)."

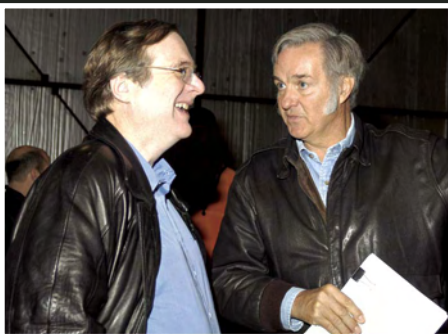
If you think that sci-fi and the "he who dies with the most toys, wins" theme isn't a strong influence at Virgin Galactic, consider that the first Virgin Space Ship is named the V.S.S. Enterprise. And Burt Rutan doesn't want his legacy to be just the design of SpaceShipOne. Instead, he says, "I

The White Knight turbojet aircraft climbs over the Mojave desert with SpaceShipOne attached below.





The White Knight launch aircraft carries the spaceship, followed by Bob Scherer's Starship chase aircraft.



Paul Allen and Burt Rutan discuss the results of a recent SpaceShipOne test flight.



SpaceShipOne shown underneath White Knight during flight 15P. Photo courtesy of Jim Campbell/Aero-News Network.

want to be remembered for helping make affordable space tourism happen, so my kids and hundreds of thousands of people can experience the magic of space."

Richard Branson is famous for spending his fortune on testosterone-pumping adventures, such as his giant hot air balloon, the first to successfully cross the Atlantic. And his boat, "Virgin Atlantic Challenger II," which crossed the Atlantic Ocean in 1986, in the fastest-ever recorded time.

And if there is any man who can rival, and perhaps surpass Branson in the "never outgrow your boyhood fantasies" department, it's Paul Allen. He owns the Seattle Seahawks, and turned his interest in and love for music into Seattle's multimedia Experience Music Project Museum, complete with a Jimi Hendrix wing. He's turned his fascination with science fiction into the Science Fiction Museum and Hall of Fame.

With a combined net worth of well over \$27 billion, as well as the track records of several highly profitable businesses behind them, the Rutan-Allen-Branson team seems well poised to pull off making a commercial success out of their collective inner-child's love for sci-fi.

In contrast, NASA's manned spaceflight efforts appear to be largely stuck for the foreseeable future, with the Space Shuttle, an early 1970s-design that's become known as the DC-3 of space — or "the DC-1 and a half," as Arthur C. Clarke once sardonically quipped after the

Challenger explosion of 1986. While NASA has successor designs on the drawing board, its bureaucracy poses deep structural problems that prevent much of a return to the glory days of Neil and Buzz. "Its fixed costs are actually very, very high," Reynolds says. "If you actually look at the NASA budget, nearly all of it goes to just keeping the lights turned on and the paychecks flowing, and there's not a lot of money left to actually do stuff."

Suborbital Bootstrapping

The current priority of Virgin Galactic is sub-orbital tourist-

oriented flights. Their preliminary travel brochures picture the flights as part of a luxurious and expensive experience, including transportation to the New Mexico spaceport, lectures, "meet the astronaut" events, and world class dining. But just as in the days of Project Mercury, suborbital space travel is a way of bootstrapping towards orbital flight — a far more significant goal.

Reynolds is not surprised that tourism is driving the initial commercialization of space travel. "People laugh at tourism as an industry, but it's something like the third biggest industry on the planet — it's huge! If space tourism were only as big as terrestrial tourism, it

SpaceShipOne glides down for approach to the Mojave airport.



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would be gigantic."

Of course, there are not only financial, but safety risks involved in developing commercial space flight. Branson said around the time of the New Mexico spaceport's debut that Virgin Airlines is "used to transporting millions of people ... transporting them safely. And we want to keep that impeccable record. We know what our priorities are."

But there were many deaths associated with aviation during its barnstorming days (they didn't call those early pilots "death-defying" for nothing). And sooner or later, there will be a Challenger or Apollo 1-like disaster during these early days of manned commercial spaceflight. Rand Simberg of Transterrestrial.com who calls himself "a recovering aerospace engineer" believes that such a setback wouldn't be permanent to this fledgling industry. "If it's clearly negligence on the part of the service provider, it will certainly be devastating for them, but not for the industry as a whole," he says. "Any more than an airplane crash killed the aviation industry in the early days in the '20s and '30s when, in fact, many died in airplanes."

But risk always encourages pioneers and adventurers. The barnstormers of the 1920s paved the way to flying becoming an everyday experience for millions of people. In a few decades, we may very well look back with similar memories of the men behind Virgin Galactic, and their colorful efforts towards helping to leave the cradle behind for good. **NV**

Photos courtesy of Scaled Composites, LLC, unless noted otherwise.



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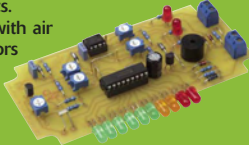
BS-5080 \$14.95 + post & packing
Australia's leading electronics magazine Silicon Chip, has developed a range of projects for performance cars. There are 16 projects in total, ranging from devices for remapping fuel curves, to nitrous controllers. The book includes all instructions, components lists, color pictures, and circuit layouts. There are also chapters on engine management, advanced systems and DIY modifications. Over 150 pages! All the projects are available in kit form.

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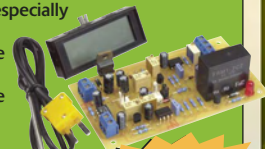
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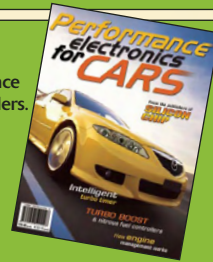
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RESISTORS

TYPES AND APPLICATIONS

by H. Ward Silver

An ohm is an ohm, right? Not so fast — there are many different types of resistors. To insure that your circuit works and stays working, use the right type of resistor. In this article, you'll learn about the common types of resistors and their special characteristics.

Resistor Fundamentals

Every conductor exhibits some resistance to the flow of electrical charge (except for superconductors). Georg Ohm discovered the exact relationship between voltage (V), current (I), and resistance (R), formulating the law that bears his name and is learned by every electronics student:

$$V = I \times R \text{ or } I = V / R \text{ or } R = V / I$$

As electrons flow through a material in response to an electric field, they collide with the atoms that make up the material. The collision transfers some of the electron's energy to the

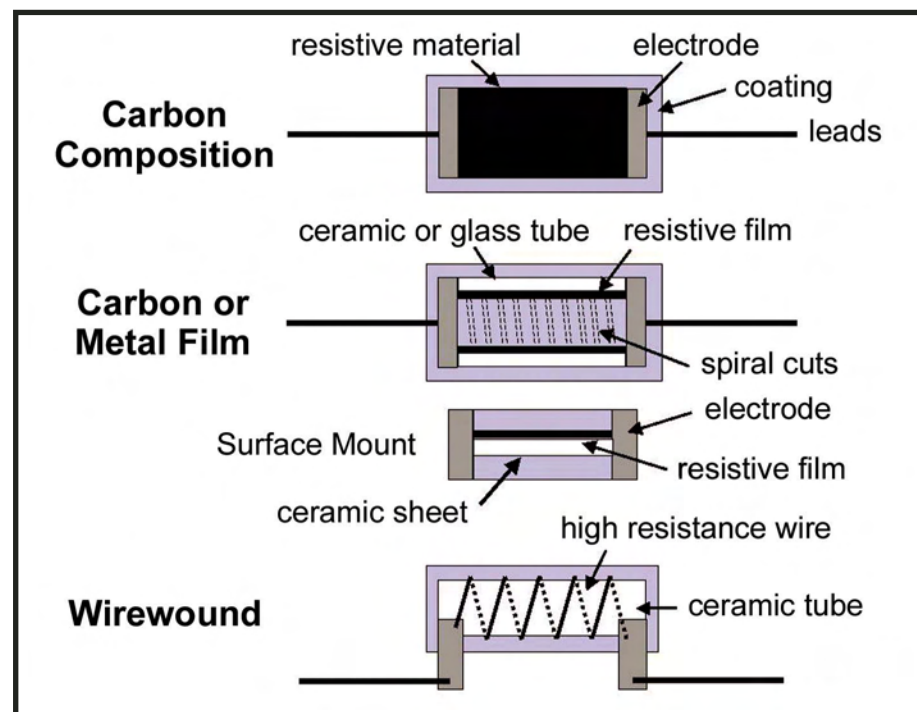
atoms, which vibrate in response. These vibrations result in an increased temperature of the material. The energy that heats the material is the power dissipated, calculated as:

$$\text{Power (P)} = I^2 \times R \text{ or } P = V^2 / R$$

A perfect resistor does not care whether the current flowing through it is AC or DC. The electrons collide with atoms going in either direction. Nevertheless, practical construction details, as shown in Figure 1, create some *parasitic* effects, making an actual resistor act like the circuit *model* shown in Figure 2. The model describes how the actual resistor's characteristics

make its electrical behavior depend on frequency and on how voltage and current are applied to it.

The series inductance, L_s , is primarily created by the leads attached to the resistor. Notice that for the surface-mount resistor, there are no leads, which greatly reduces L_s . The electrodes also form a very small capacitor, C_p , that affects the resistor's behavior at very high frequencies. Although the resistor's coating is a very good insulator, current can still flow in very small amounts across the surface of the resistor as a *leakage current*, represented by R_p . This becomes important when the resistor has a very high value or is



FURTHER READING

To learn more about resistors, definitions are available from the Resistor Term Glossary at www.prpinc.com/pdf/GlossaryofTerms.pdf. Download the article on choosing resistors "Ask the Applications Engineer #24" from Analog Devices' website at www.analog.com/library/analogDialogue/archives/311/Ask_Engineer.html. Serious designers will want to find a copy of *The Resistor Handbook* by Kaiser (CJ Publishing, 2851 W. 127th St., Olathe, KS 66061) which is a good reference.

FIGURE 1. Resistors can be constructed in a number of ways to optimize power handling, stability, or size.

FIGURE 2. This is a model of how a resistor actually behaves in a circuit. The type of resistor determines the importance of each component.

used in a high voltage circuit.

Resistor Types

For a piece of conducting material to be made into a practical resistor, a pair of electrodes and leads are attached so that current can flow. The resistor is coated with an insulating material to protect the conducting material from the surrounding environment and vice versa. There are several different resistor construction methods and body styles or *packages* that are designed for a certain range of applied voltage, power dissipation, or other considerations.

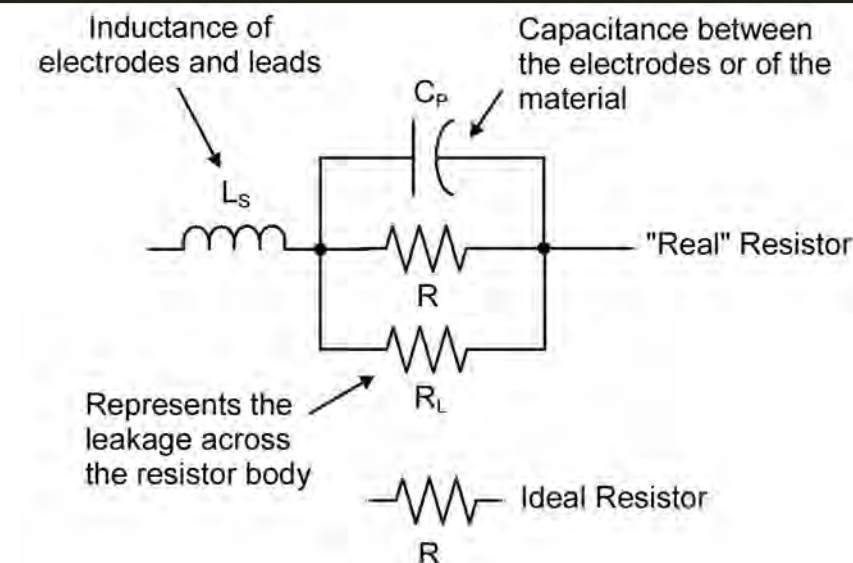
Carbon Composition

Composition means that the resistive material is a mix of carbon and stabilizing compounds. The amount of carbon in the mix determines the resistance of the material. A small cylinder, like a pencil lead, is held between the two electrodes and coated with resin or phenolic, making a *non-inductive* resistor with low L_S that is often used in RF circuits.

Carbon comp resistors are available with power ratings of 1/4 to 2 watts. They can also handle temporary overloads much better than film resistors because the heat is distributed evenly throughout the cylinder of resistive material. That makes them a good choice for circuits that protect against and absorb pulses and transients, for example. Unfortunately, these resistors are also strongly influenced by temperature and humidity and so are not good for circuits that depend on precise, stable resistance values.

Film Resistors

In a film resistor, the resistive material is a very thin coating of carbon or metal on an insulating substrate, such as ceramic or glass. The value of the resistance is determined by the thickness of the film and the amount of carbon or metal in



it. These resistors are available with very accurate and stable values.

A drawback of film resistors is that they are unable to handle large amounts of power because the film is so thin. Overloads can also damage the film by creating "hot spots" inside the resistor, changing its value permanently. The value of film resistors is sometimes adjusted before sealing by cutting away some of the film with a laser, a process called *trimming*.

If the film is deposited on the inside of a tube, the trimming process creates a coil-like current path that raises the L_S of the resistor. If your circuit operates at high frequencies, be sure the resistors you

select have a low value of L_S .

Surface-mount resistors are almost always film resistors. These resistors have no leads at all, so L_S is very low. The film is deposited on a ceramic sheet. Because of their extremely small size, surface-mount resistors have very low power ratings — from 1/10 to 1/4 watt.

Wirewound

Common in power supplies and other equipment where lots of power is dissipated, a wirewound resistor is made just as you might expect. A high-resistance wire is wound on an insulating form — usually a ceramic tube — and attached to electrodes at each

CHOOSING RESISTORS

Here are some special applications that require special types of resistors. These aren't hard and fast rules, but can guide your initial selection. For most circuits, plain old carbon film or carbon comp resistors will work just fine.

- ESD and Transient Protection — Carbon composition, metal oxide (withstand short pulse overloads and low inductance)
- Audio and Instrumentation circuits — metal film (low noise)
- High Voltage — wirewound and metal oxide in high-voltage body styles
- RF — carbon composition and metal oxide (low inductance)
- Precision circuits — carbon or metal film (fixed value) and cermet (trimmers or controls)

Remember to consider what is important for your circuit — value, power or voltage, stability, cost — then look for the resistor type that meets those requirements.

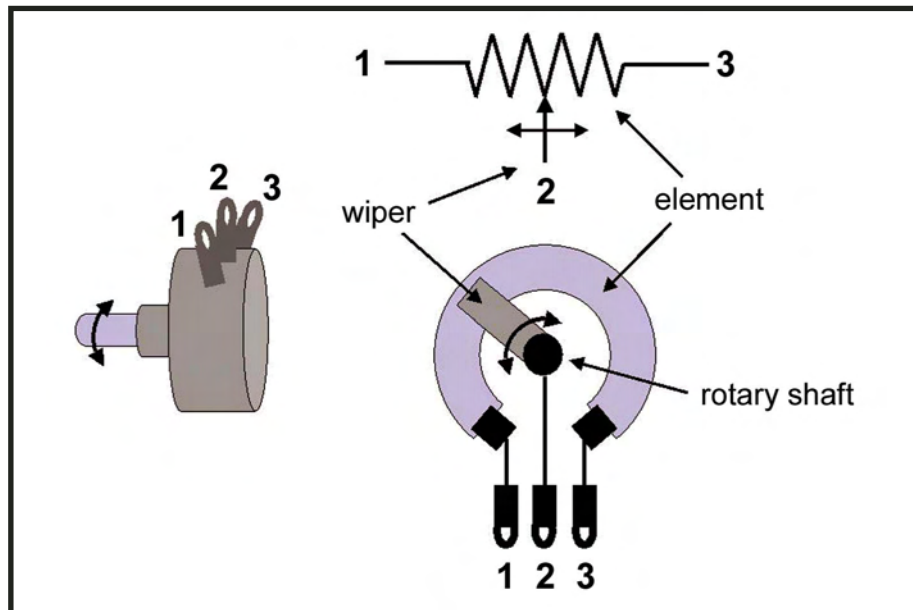


FIGURE 3. A potentiometer (or pot) acts as a variable voltage divider by moving a wiper across the surface of a fixed-resistance element.

end. These are made to dissipate a lot of power in sizes from one-watt to hundreds of watts! Wirewound resistors are usually intended to be air cooled, but some styles have a metal case that can be attached to a heatsink or metal chassis to get rid of undesired heat.

Because the resistive material in these resistors is wound on a form, they have very high L_S . For this reason, wirewound resistors are not used in audio and RF circuits. Be careful when using a resistor from your junk box or a grab bag in such a circuit!

Small wirewound resistors look an awful lot like film or carbon comp resistors. There is usually a wide color band on wirewound resistors, but not always. If you're in doubt, test the resistor at the frequencies you expect to encounter. There are special versions with windings that cancel

most of the inductance, but have a much higher C_P that also affects the resistor's performance above 50 kHz.

Ceramic and Metal Oxide

If you need a high-power non-inductive resistor, you can use *cermet* (ceramic-metal mix) or metal oxide resistors. These are constructed much like a carbon comp resistor, substituting the cermet or metal oxide for the carbon composition material.

Adjustable Resistors

There are many different types of adjustable resistors. The simplest are wirewound resistors with some of the wire exposed so that a movable electrode can be attached. The most common are adjusted with a rotary shaft as shown in Figure 3. The *element* provides a fixed resistance between termi-

nals 1 and 3. The *wiper* moves to contact the element at different positions, changing the resistance between either end of the element and terminal 2.

If an adjustable resistor has only two terminals (1 and 2 in the figure), then it is called a *rheostat* and acts as an adjustable resistance. Most rheostats are intended for use in high-power circuits with power ratings from several watts to several tens of watts.

If the adjustable resistor has three terminals, it is called a *potentiometer* or "pot" for short. Most pots are intended to act as voltage dividers and can be made into a rheostat by leaving terminal 1 or 3 unconnected. Miniature versions called *trimmers* mount on a circuit board and are used to make small adjustments or calibrate a circuit. They are available in single-turn or multi-turn versions.

Larger pots with 1/8" or 1/4" diameter shafts are intended for use as a user control. Pots are available with resistance values from a few ohms to several megohms and with power ratings up to five watts.

Like fixed-value resistors, the construction of the pot is important. Higher-power pots may have a wirewound element that has enough inductance to be unsuitable for audio or RF signals. Smaller pots, particularly trimpots, are not designed to be strong enough for use as a frequently-adjusted control. Most pots have relatively high values of C_P , as well.

Pots are also available with elements that have a non-linear *taper* or change of resistance with wiper position. For example, a *log taper* pot has a resistance that changes logarithmically with shaft rotation. This is useful in attenuator circuits, for example. An *audio taper* pot is used to create a voltage divider that mimics the loudness response of the human ear so that volume appears to change linearly with control rotation.

Resistor Networks

In order to save space on printed

TOLERANCE AND TEMPERATURE COEFFICIENT

Resistors have a *nominal* value and a *tolerance* (the amount of acceptable variation above or below the nominal value). Most resistors have a 1%, 5%, or 10% tolerance and you can find smaller or *tighter* tolerances. Which values of resistors are available is determined by the *tolerance series*. For example, in the 5% series, values are selected so that each is approximately twice the tolerance or 10% from the next highest or lowest value.

Resistors also change value with temperature. The relative change of resistance with temperature is called the *temperature coefficient* or *tempco* and it is specified as *parts per million* or *ppm* or as percentage change per degree Celcius of temperature change. A positive tempco means that resistor value increases with temperature. When designing and constructing sensitive circuits that use precision (1% or tighter tolerance) resistors, it is important to keep them at an even temperature.

circuit boards, resistor networks are often used. These are miniature printed circuits themselves, placing several resistors on one substrate. The resistors may be isolated from each other, share one common terminal, or be connected in series. There are a number of configurations that can be found in any component supplier's catalog.

Power Dissipation and Voltage Ratings

After value, power dissipation is the next most important characteristic of a resistor. An overloaded resis-

HOW TO READ A RESISTOR

Learning the resistor color code ("Bad boys ravish ...") is a rite of passage for electronics techs the world over. A handy Web guide is available at www.proaxis.com/~iguanalabs/resistors.htm along with other handy tutorials, or just type in "resistor color code" to an Internet search engine. Surface mount and power resistors may also have the value printed on their body as a three- or four-digit code with the final digit acting as an exponent. For example, '513' means 51×10^3 or 51K Ω .

more than a watt, arrange nearby components so that air can circulate freely. If possible, mount power resistors horizontally so that convection cools all parts of the resistor equally.

ing current to leak around the internal resistance. High-voltage resistors must be kept clean. Fingerprints, oil, dirt, and dust all create unwanted current paths, lowering R_p and increasing leakage or

An ohm is an ohm, right? Not so fast — there are many different types of resistors. To insure that your circuit works and stays working, use the right type of resistor."

tor often changes in value over time and can often get hot enough to burn itself and surrounding components. Every circuit designer learns the smell of burnt resistor sooner or later!

The common rule of thumb is to calculate how much power the resistor will have to dissipate and then use the next largest size or a factor of two higher dissipation rating, whichever is larger. The power rating is based on unobstructed air circulation around the resistor. For resistors dissipating

Another important rating is *maximum applied voltage*. Voltages above this value may cause an arc between the resistor terminals! At high voltages, R_p can also become significant, allow-

even arcing. This is why resistors for use in high-voltage circuits are long and thin with their terminals far apart — to minimize leakage and maximize the ability to withstand high voltage. **NV**

ABOUT THE AUTHOR

H. Ward Silver is an engineer, writer, and teacher with over 30 years of practical experience in medical electronics, instrumentation design, and broadcasting. He is the author of *Two-Way Radios and Scanners for Dummies* and *Ham Radio for Dummies* by Wiley Press and numerous articles for QST magazine. Ward's ham radio call sign is NQAX.

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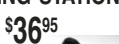
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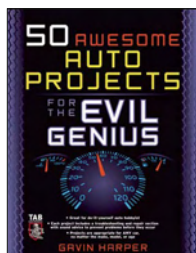
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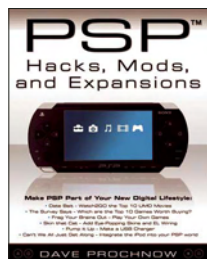


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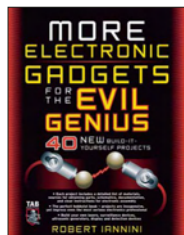
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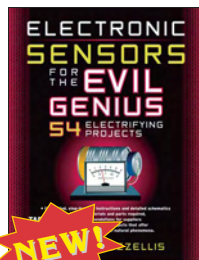
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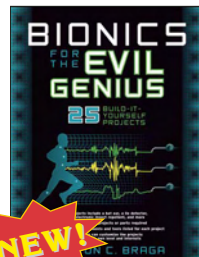
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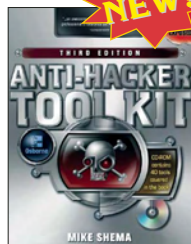


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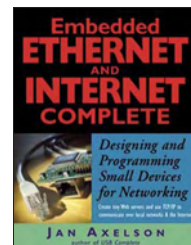
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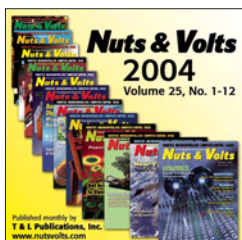


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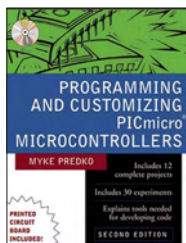


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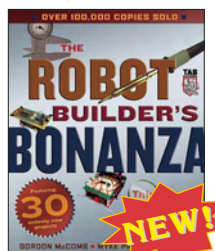
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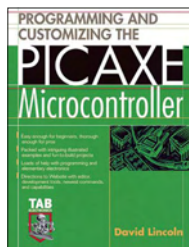
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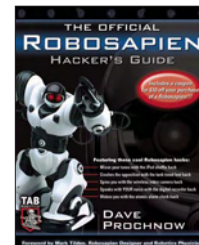


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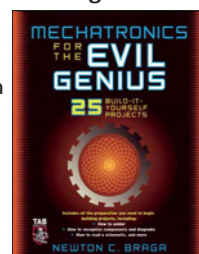
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by Newton C. Braga

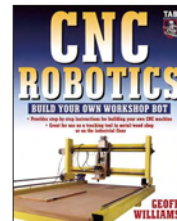
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Getting Started With PICs

⇒ PIC to PC Communication

by **Chuck Hellebuyck**

⇒ As I write this, my first “Getting Started with PICs” article has been published and the email response has been outstanding. Apparently, a lot of people like the topic and want to know more about getting started with PICs. Being able to write these articles is really a joy for me because I have a real passion for programming PICs and I learned a lot of it the hard way — via trial and error.

Having the chance to share my knowledge with others is only beneficial, though, if someone wants to read it. The feedback email proves a lot of people are reading. Feedback also tells me what readers want to see, and I can form my future articles around that feedback. It's just a great example of two-way communication. That's also the topic of this month's column — communication.

Think about it. A major portion of your monthly bills are dedicated to communication — your phone bill (both land line and cell), your cable TV bill, your Internet bill, your magazine subscriptions, books you buy, maybe even a satellite radio bill — they are all forms of communication we are willing to pay for. This month, I want to address one form of PIC-to-PC communication using serial RS232 format, and you get this one for free (excluding the magazine subscription fee).

Before I received my first computer as a gift — a Commodore VIC20 — I was fascinated with computer control. Many years ago, I interfaced a circuit built around a chip I found at RadioShack, which made the VIC20 talk via its expansion port. Nobody in my family seemed to care too much, but I was excited that I had figured out how to control external electronics from a computer. There have since been many books written on how to use the parallel port or serial port on a PC to control electronics, and USB is taking over as the communication port of choice.

Despite the USB revolution, the RS232 serial port interface is still the most common method of communicating with various off-the-shelf modules found in the pages of *Nuts & Volts*. You can get RS232 style serial LCDs, dataloggers, servo motor controllers, and DC motor controllers, just to name a few. You can also find loads of Windows PC software all over the web that will accept or send ASCII data from the serial port.

Therefore, in my opinion, one of the fundamental projects every PIC

hobbyist should know is how to communicate between a PIC and a PC serial port. After that, you can add an RS232 to USB converter if you need USB.

GETTING STARTED

For this article, I wanted to keep it simple and demonstrate how to have a PC user control a bank of LEDs. By entering the number on the PC, the user can turn on a specific LED at a remote location only connected to the PC by a serial cable. The remote module will have a PIC to handle the interface and start the communication by sending a message to the PC asking which LED to light. The PC user enters their choice, hits the “enter” key, and the PIC circuit receives it and then lights the proper LED. It's simple two-way communication with a functional purpose.

For the software — once again — I turn to the PICBasic Pro sample version to handle the software. At the end of the article, though, I'll address some of the options for going beyond the sample version's limitation of 31 commands, as some email has

⇒ **FIGURE 1.**
The connection setup.

requested. For the hardware, the PIC16F876A fits the job perfectly.

The PICBasic Pro compiler offers two ways to implement serial communication: the SEROUT and SERIN commands, which are the software implementation of serial “bit-banging” communication, and the HSERIN and HSEROUT commands, which implement the hardware serial port on the PIC that runs in the background.

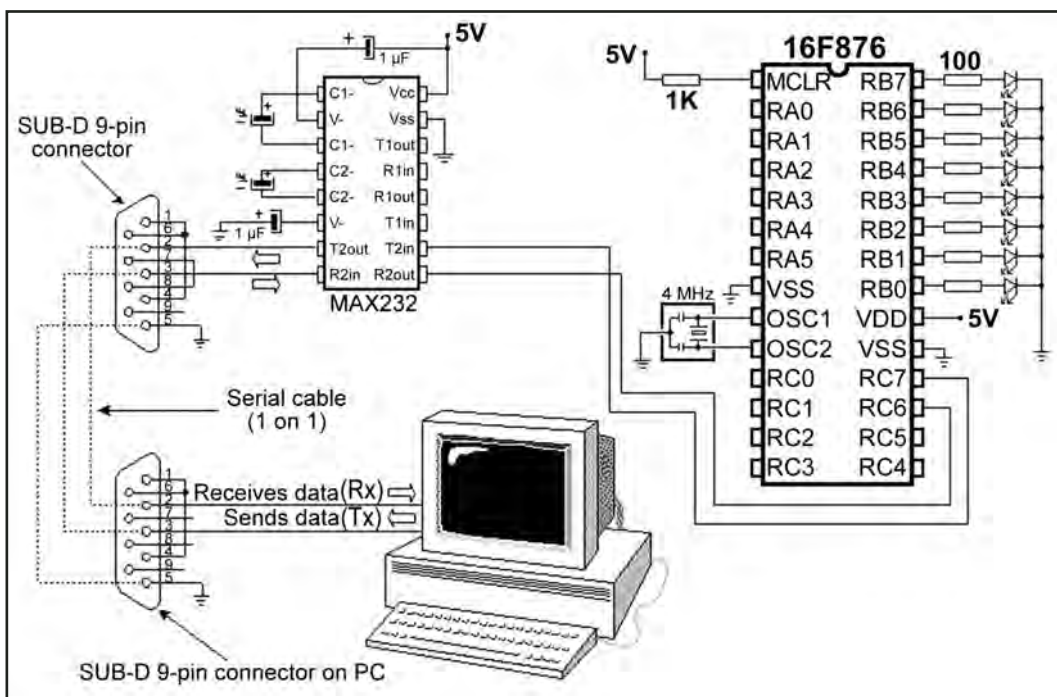
What I mean by background is the hardware serial port can send and receive serial data while a main loop of code is also running at the same time. I felt this was a little too advanced for the beginner, so I’ll use the SERIN/SEROUT here and save the hardware commands for another application.

PROJECT DESCRIPTION

The project I’ll present here may be simple, but it’s also a building block for bigger projects in the future. I’m going to control a bank of eight LEDs from the Hyperterminal terminal program found on most PCs running Windows. The serial cable will connect the PC’s serial port to an RS232 interface circuit built into the remote PIC/LED circuit. The interface circuit will adjust the signal voltage levels to what the PIC/PC need to see.

At some point, I’ll introduce this same RS232 interface circuitry to program the PIC in-circuit via bootloader mode, but for now, all programming will be done with the EZPIC serial port programmer.

Figure 1 shows what I’m trying to describe. The PC connects to the RS232 circuit through a straight-thru nine-pin cable. The RS232 circuit uses a standard MAX232 style chip with built-in charge pump to match the 0-5V PIC signal and -12V to +12V PC signal. The PIC16F876A has the



standard PIC circuit connections with a 4 MHz resonator and MCLR pull-up resistor. The LEDs are connected to Port B and are driven on with a high signal from the individual Port B pins.

RS232 BASICS

Serial communication can send any data you want as long as it comes in the form of bytes. It can take on many forms, and one is called the RS232 standard. In Figure 2, I show a typical RS232 signal format. The first pulse is low and that is called the start bit. After that, eight bits are sent, which is a byte of data. Following the data is a high bit, which is the stop bit or end-of-data indicator.

Every character a computer can show has a numerical code associated with it, and there are 256 different codes (the maximum amount for eight bits). This just means that there are 256 different characters that can be sent as a byte inside a serial message. This ASCII code table can be found with a simple Google search.

This RS232 signal format I described is known as 8N1 or eight

⇒ **FIGURE 2. RS232**
signal format.

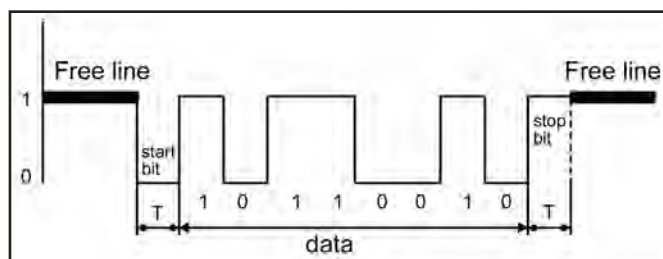
data bits, no parity check, and one stop bit. Later, we’ll set up the Hyperterminal program to receive 8N1 data at a speed of 9600 bits per second.

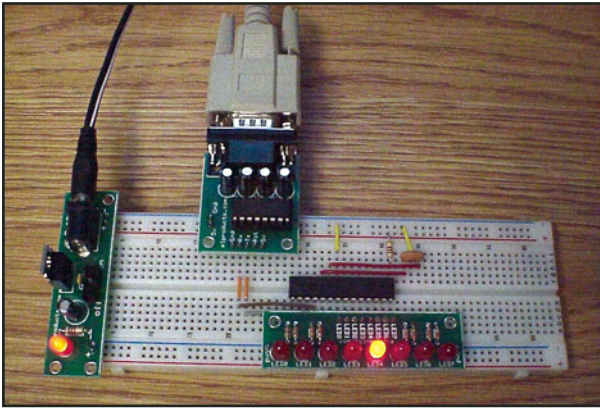
Since the PC and PIC have to communicate in the same language to understand each other, the width of the pulses is critical to determine if a pulse is actually multiple 1s or 0s, or a single bit. Timing is, therefore, very important to the success of communication.

Matching the bit rate between the PC and PIC confirms the PIC and PC are talking the same version of the language. It’s like trying to watch an American citizen speak with a British citizen. They both speak English but sometimes they need a little help with interpretation.

SOFTWARE

The PICBasic Pro program is shown in Listing 1, which is available on the





↑ **FIGURE 3. Hardware setup.**

Nuts & Volts website at www.nutsvolts.com Let's step through it section by section.

Two variables are created named "old" and "new." These will be used to store the LED number to light and which one to turn off.

```
old var byte
new var byte
```

Next, the ports are set up for their proper input and output mode. Remember, on a PIC a "0" makes the pin an output and a "1" makes the pin an input. In this project, Port C pin 6 is the transmit pin and is made into an output. Port C pin 7 is the receive pin so it's made an input. The rest of the port pins are also made into inputs since that puts them in a safer high impedance mode.

```
TrisC = %10111111
```

All the LEDs are connected to Port B, so we make these outputs. We could actually skip these steps since the SEROUT and SERIN commands along with the HIGH and LOW commands set the proper mode automatically, but it's best to learn this way of controlling the PIC in your programs.

```
TrisB = %00000000
```

The main loop of code starts with the "main" label. The first com-

↓ **FIGURE 5. Connection setup window.**



← **FIGURE 4. The screen that sets up the connection file name.**

mand implemented is the SEROUT command that sends the statement; "Enter which LED to light (0-7):" out to the PC. Anything within quotes in the SEROUT command will be sent as it's seen.

In other words, the SEROUT will automatically look up the ASCII

code for each character and send those codes out serially. The 10 and 13 that follow are the ASCII number codes for line feed (10) and carriage return (13). The results of this command will be displayed on the Hyperterminal screen, as shown in Figure 7.

```
main
serout portc.6, 2, ["Enter which LED to light (0-7): ", 10, 13]
```

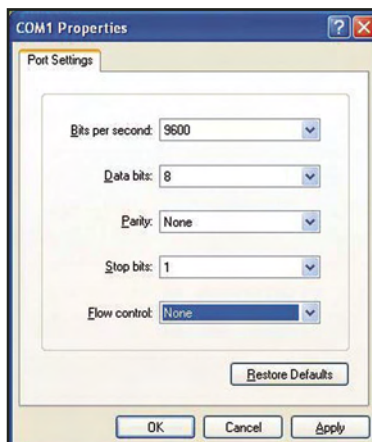
The SERIN command comes next, and it just waits for a response ASCII code to be sent from the PC user. One thing I didn't point out is the format. The pin being used for SERIN or SEROUT follows the command and then a number "2" follows that. The "2" represents True 9600 bits per second in PICBasic Pro language. If you have the full version of PICBasic Pro, you can also enter T9600 instead of "2" when you include a definition file at the top of the program. But the sample version doesn't allow "includes," so you have to use the raw "2" value.

After the "2" in the SERIN line is the pound sign and the variable "new." What the pound sign does is tell SERIN to receive the ASCII value and then convert it into the actual numerical value it represents. For example, the ASCII code for the number "1" is actually 31h. When the PC user chooses to light LED1, 31h is sent to the SERIN command and is then converted to decimal value one.

```
serin portc.7, 2, #new
```

Converting "new" to the numerical value "1" (binary 00000001) instead of the ASCII character "1" (binary 00110001) allows us to directly use the variable as the pin number in the HIGH command to drive the proper LED. Before we get to that, though, the program sends the value received back to the PC as the ASCII value by putting the # sign in front of the variable. This converts the contents of the variable "new" to the ASCII code for sending it, but doesn't change the actual value of the contents of the "new" variable. This is just a way to feedback to the PC user the PIC received the proper value. You can see that in Figure 7, also.

← **FIGURE 6. Shows the setup as 9600 bits per second, eight data bits, no parity, and one stop bit.**




```
serout portc.6, 2, ["LED Chosen: ", #new, 10, 13]
```

The program pauses to allow the PC to get the data. I just threw this in as a precaution since some PCs can run a little slow.

```
Pause 100
```

Now the LEDs are controlled with simple HIGH and LOW commands. The previous LED value is stored in the variable "old" and the LED is turned off with a LOW signal on that pin.

```
low old
```

A HIGH signal on the "new" LED value just received turns the selected LED on.

```
high new
```

The "old" variable is made to match the "new" variable so the next time through, the program will shut off the lit LED.

```
old = new
```

The last step is to jump to the top of the program at the "main" label so it can all be done again.

```
goto main
```

HARDWARE

I cheated a little on the hardware setup shown in Figure 3. I like to build most of my projects on breadboards, so I developed a bunch of breadboard modules. I used three of them here which made the setup go faster. You can easily build the same setup with discrete components.

The PIC16F876A is plugged directly into the breadboard and has the resonator and pull-up resistor installed with it. The RS232 interface circuit is one of the breadboard modules which is shown connected to the serial cable. The LEDs are another breadboard module and the connection header lines up perfectly with the PORT B pins of the PIC, saving me jumper wires.

The PIC gets its five-volt power from the breadboard rails which are connected to one of my breadboard power modules. This makes it easy to connect an AC adapter to the breadboard.

The power module has pins that line up with the breadboard rails to

⇒ **FIGURE 7. The final working screen showing the communication lines the PIC sent out and my response.**

supply five volts and ground throughout the breadboard. Both the RS232 and LED module have pins that plug into the power rails so I save more jumpers. Okay, it goes beyond being lazy. If I had a dollar for every mis-wired jumper that left me pulling my hair out blaming my code, I could probably retire.

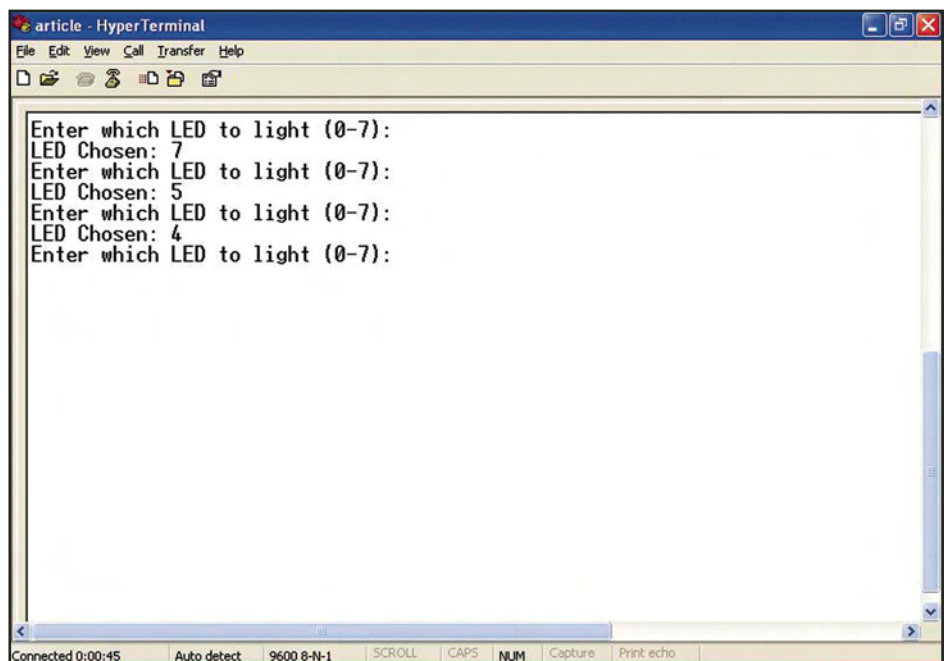
HYPERTERMINAL

Setting up Hyperterminal for proper communication takes a few steps. The first step is to open Hyperterminal and you will be asked to open a new connection. Actually, this is the first step in Windows 98. If you use XP or some other version of Windows Hyperterminal, you'll be asked for a phone number and other information before you get to the screen in Figure 4. Just enter a bogus phone number and follow through until you get to the screen shown.

The screen in Figure 4 sets up the connection file name. Enter the connection name you want and click "OK." Then the connection setup window will pop up asking for your connection method, as shown in Figure 5 (you might have to go through a few more bogus entry screens). From the selection window, choose the serial port you want to connect to. In my case, it was COM1.

Click "OK" and you'll be asked to choose your connection format. Figure 6 shows the setup as 9600 bits per second, eight data bits, no parity, and one stop bit. You also want to make the flow control selection "none." After you click on "OK," you're ready to receive data.

The final working screen is shown in Figure 7. It shows the communication lines the PIC has sent out and shows my response, as the PC user, three different times. The last one chose to turn on the fourth LED, as shown lit in the hardware picture of Figure 3. The best way to start is to get everything connected and start the Hyperterminal connection. Then turn off the PIC circuit and back on so the "Enter which LED to light (0-7):" shows up on the terminal screen.



NEXT STEPS

You can see communication from PIC-to-PC and PC-to-PIC is not that difficult to accomplish. In this example, we controlled LEDs from the PC, but the LEDs could easily be replaced with transistors and relays so the PC could be controlling something more powerful.

Eventually, you could add switch inputs or sensors to the PIC circuit and then read the state of the

switches or sensors and send the results to the PC. Now, replace the Hyperterminal with a nice GUI based program written in Visual Basic or similar and you have a professional looking PC control system.

MOVING ON FROM 31 COMMANDS

The 31 command limit sample version of PICBasic Pro hasn't

slowed us down, but if you want to use other PICs and larger programs, then the PICBasic Pro compiler may be worth the investment. It retails for \$249.95, but I sell it for \$10 off to my website visitors. I also sell a product called the Atom. It's better known as a BASIC Stamp competitor, but in reality, it's the free-to-download Atom Basic compiler and Atom interpreter chips that are the stars. The chips are either a PIC16F876A or PIC16F877A with a custom Atom bootloader self-programming code installed.

The Atom modules are the same footprint as the BASIC Stamp modules, but are built around these PIC16F876A and 877A PICs. The Atom Basic compiler is closer to the PICBasic Pro compiler, giving you access to all the internal PIC features. The only catch to use the "free" compiler is you have to connect an Atom module or Atom chip to your PC serial port or USB port (with Serial to USB adapter) to use the compiler, so it's not completely free in the long run, but definitely inexpensive. I have those modules and chips, along with some of my own Atom module designs, at my website www.elproducts.com and it's one of my favorite PIC development tools.

I'll also talk more about other programming options in future columns, including some new stuff direct from Microchip and eventually touch on assembly language programming. I just wanted you to know these columns are taking you further than just 31 command sample versions.

I'm also excited to announce I released my second book to follow my PicBasic book. It's titled *Programming the Basic Atom Microcontroller* and is written about the Atom chips I mentioned above. The book is written for the beginner to intermediate users who may want more than a monthly column can deliver. It is also available in the *Nuts & Volts* bookstore (www.nutsvolts.com). Lots of communicating going on, so I hope you are enjoying it. Thanks for reading and, as usual, email me with your feedback to chuck@elproducts.com **NV**

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■ BY JAMES ANTONAKOS

A GOOD LISTENER REQUIRES A GOOD TALKER

Some Fun With Speech Synthesis

"HELLO, PLEASE TALK."

"THIS IS SO SIMPLE, I CANNOT BELIEVE IT."

Alright, those are hardly as dramatic as "Watson, come quick! I need you!" but they are just as satisfying because they are the third and fourth things my new speech board said to me. To find out what the first two phrases were, read on.

As a beginning instructor at my college (okay, it was 1984), I became fascinated with computerized speech. I spent months playing with the Votrax phoneme synthesizer and the National Semiconductor DigiTalker. Imagine my glee when one of my recent students told me he had seen a new speech synthesizer called the SpeakJet.

I immediately searched the Internet for it, as I was interested in having my senior students do a speech project for their capstone course. I found the SpeakJet at www.speechchips.com. The SpeakJet (manufactured by Magnevation) is an

18-pin DIP IC that runs on five volts and requires a minimum of parts to produce speech (just a speaker will get you started). Here are some of the SpeakJet's features:

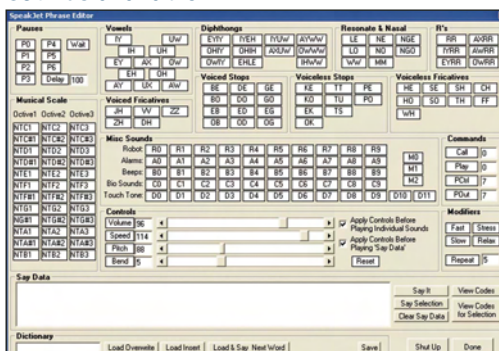
- Programmable five-channel synthesizer
- Natural phonetic speech synthesis (72 speech elements called allophones)
- 12 DTMF tones and 43 other sound effects
- Control of pitch, rate, bend, and volume
- Multiple modes of operation
- Simple interface to microcontrollers
- Three programmable digital outputs
- Internal 64 byte buffer
- Internal programmable EEPROM
- Extremely low power consumption

ing, and asked if I could have a loaner to play with. He agreed, and a short while later, I received his sample. Before I had time to experiment with the SpeakJet, Kenneth sent me the newest product from **Speechchips.com** — the TTS256 Text-To-Speech translator. This 28-pin DIP IC uses a 600-rule database to convert an ASCII text string into the correct SpeakJet sequence of phonemes/allophones. This is exactly what I was looking for. I was shocked at how easy it was to get everything up and running. Here is a brief timeline of my activities once I opened the SpeakJet sample mailed to me:

1. First, I studied the manual for the SpeakJet Supercarrier PCB. It took about 10 minutes to familiarize myself with all the jumper settings. I looked at the schematic of the PCB at the same time, which helped me understand what the jumpers actually did.

2. Next, I spent another 10 minutes

■ **FIGURE 1.** PhraseAlator application window. The PhraseAlator controls the SpeakJet through a 2400 baud serial connection and can be used to play any sound or combination of sounds available.



I contacted Kenneth Lemieux (*no relation to the publishers*) at **Speechchips.com**, told him I thought the SpeakJet was interest-

ACKNOWLEDGEMENTS

I would like to thank Kenneth Lemieux for providing me with a SpeakJet Supercarrier board and TTS256 chip to play with, as well as his interesting thoughts on speech synthesis technology. Thanks also to Jim Hewitt for designing such an easy-to-use PCB for the SpeakJet.

wire wrapping power, ground, and speaker wires to the PCB. I set my DC power supply to eight volts (there is an on-board 7805 regulator on the PCB to make +5 volts) and connected the power lead. The speaker instantly said "Ready." Wow! What a nice indication that the PCB is working. This, by the way, was the first thing the SpeakJet said to me.

3. Next, I installed the PhraseAlator application, which allows you to control the SpeakJet via a serial connection. Figure 1 shows the application window. Clicking on a sound icon — such as any of the Robot sounds R0 through R9 — instantly plays the sound sample (allophone) on the SpeakJet. All allophones required to synthesize human speech are available in the PhraseAlator, plus many other useful sounds, such as the Touch Tone and Musical sounds. The PhraseAlator controls the SpeakJet via a serial cable from the PC's COM port, operating at 2400 baud. The PhraseAlator requires the registered file MSCOMM32.OCX to operate. Simply place a copy of the file in the \windows\system folder and then run the REGSVR32 application to register the file, as in:

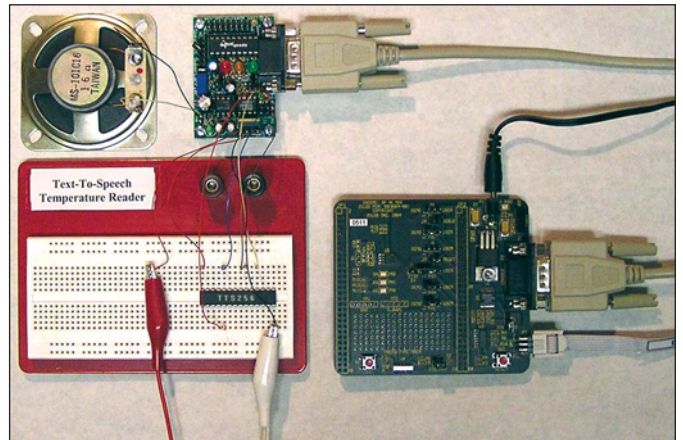
```
regsvr32 \windows\system\mscomm32.ocx
```

The PhraseAlator, SpeakJet manual, and MSCOMM32.OCX are all available via download.

4. After playing with the PhraseAlator for several minutes, listening to all the different sounds (these sounds are the second 'thing' the SpeakJet said to me), I then interfaced the SpeakJet PCB with the 28-pin TTS256 Text-To-Speech translator designed specifically for the SpeakJet. You just send an ASCII text string to the TTS256, such as "Hello, please talk," and the TTS256 does all the work of controlling the SpeakJet to make the required words come alive.

The ASCII text string is sent to the TTS256 in serial form also, at a speed of 9600

■ FIGURE 2. Here is the setup on my workbench that interfaces the Z8 Encore! XP development board to the SpeakJet and TTS256. The SpeakJet super-carrier PCB is at the top to the right of the speaker. The TTS256 is plugged into the large protoboard.



baud. Figure 2 shows the results of my breadboarding.

The TTS256 (like the SpeakJet) requires a TTL serial waveform (eight data bits, no parity, one stop bit, abbreviated as 8N1). An IC on the SpeakJet supercarrier PCB (the eight-pin DS275) converts from RS232 levels to TTL.

By carefully tapping into signals available on the PCB, and by setting the jumpers appropriately, I was able to use the DS275 to drive the TTL signals on the TTS256. The TTS256, in turn, controls the SpeakJet with its own TTL serial connection, as illustrated in Figure 3.

5. Before connecting the Z8 Encore! XP as the host controller, I used my PC and ran HyperTerminal to communicate with the TTS256. I configured HyperTerminal for 9600 baud and 8N1, established a connection, typed in the phrase "Hello, please talk," and pressed Enter. The words "Hello please talk" played out on the speaker. I was so pleased, I entered a second phrase and heard "This is so simple I cannot believe it" come out next.

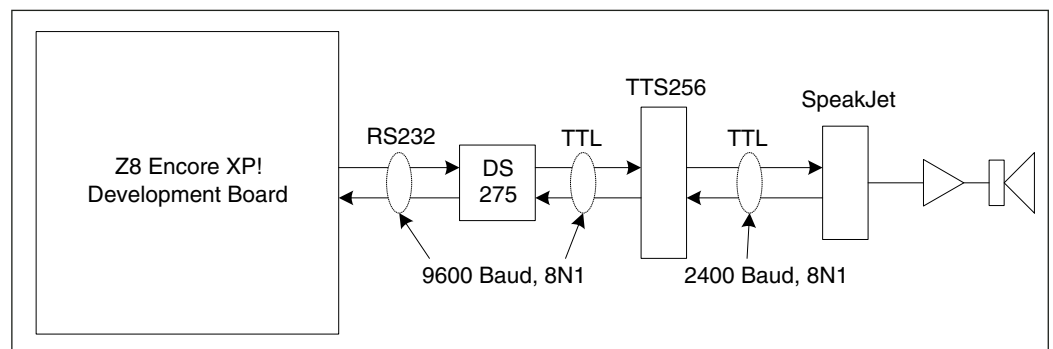
6. Now the challenge was to get the Z8 Encore! XP to make the TTS256-SpeakJet system say something use-

ful. I searched ZiLOG's application notes for the XP development board, and eventually found AN0191.PDF, titled 'Reading Temperature Using the Z8 Encore! XP MCUs.'

A companion ZIP file, AN0191-SC01.ZIP, contained the compiler project files for the temperature application. This is where I spent the most time, learning how the application worked and then modifying it to send the proper ASCII strings to the TTS256. Part of this effort required a change from ZiLOG's standard 38,400 baud rate to the slower 9600 baud used by the TTS256. I also had to set the Flow Control parameter to None in the COM port properties.

In addition, I had to add enough of a pause between messages to allow the SpeakJet to do its talking. Sending the messages too fast resulted in dropped words, as well as portions of words pronounced incorrectly. I spun my wheels for a while trying to get the wrong project working (it was not designed for the XP) and looking at

■ FIGURE 3. Simplified diagram showing the connections between the host controller (the Z8 Encore! XP), the TTS256, and the SpeakJet.





| Name | Title | Description |
|------------------|--|---|
| Bob Dempsey | Display Interface | Control a HD44780-type LCD. |
| Frank Derryberry | Two-Channel Serial Thermocouple Interface for a PC-based Data Logger | Read (2) K-type thermocouples and communicate their values to a PC using its serial communication port. |
| Ken Fallot | Power Monitoring Subsystem | Real-time acquisition and monitoring of multiple power circuits. |
| Tim Gilmore | 911 Fire Alarm Box Addressing | Map of hundreds of fire alarm boxes to a real-time LED map, with alphanumeric LCD status readout. |
| John Havel | Closed-Loop Barn Technology | Cows are kept safe and happy with their environment electronically controlled. |
| Bob Hyland | Automatic Cat Feeder | Ring a bell to signal feeding time and control the food mechanism. |
| Steven Janigian | Automatic Ticketer for Speeders | Combine a radar gun, digital camera, and ticket printer, and make the roads safe again. |
| Kenneth Tindle | X10 Controlled Zoned Audio | Use off-the-shelf technologies in a system to provide zoned whole house stereo audio at low cost. |
| Steve Woodruff | Automotive Status Monitor | Talk to the CAN bus interface in a Toyota Prius Hybrid car. |
| Dan Youngs | Automated Light Control | Control all navigation lights in a commercial bus. |

■ TABLE 1. Z8 Encore! XP design contest proposal summary.

REFERENCE

To obtain your own SpeakJet IC, Supercarrier board, or TTS256 chip, visit www.speechchips.com. For a special *Nuts & Volts* reader discount, use the following discount code: NV10. This discount code provides a 10% discount for orders over \$10.

Contact Information:
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Portland, ME 04112
Voice and FAX:
(928) 569-4997

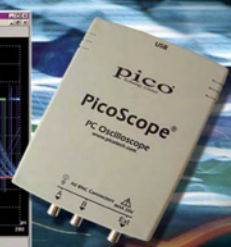
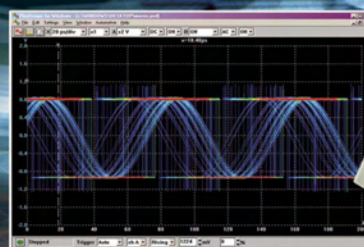
the wrong documentation (it was not for the 4K board).

7. When I finally heard the words "The temperature is 71 degrees" come from the speaker, I had reached my

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| PicoScope | 3204 | 3205 | 3206 |
|-----------------------------|----------------------------|-----------------------|-----------------------|
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| Sampling rate (repetitive) | 2.5GS/s | 5GS/s | 10GS/s |
| Sampling rate (single shot) | 50MS/s | 100MS/s | 200MS/s |
| Channels | 2+Ext trigger | 2+Ext trigger/Sig gen | 2+Ext trigger/Sig gen |
| Oscilloscope timebases | 5ns/div to 50s/div | 2ns/div to 50s/div | 1ns/div to 50s/div |
| Timebase accuracy | 50ppm | 50ppm | 50ppm |
| Spectrum ranges | 0 to 25MHz | 0 to 50MHz | 0 to 100MHz |
| Buffer memory size | 256KB | 512KB | 1MB |
| Resolution / accuracy | 8 bits / 3% | | |
| Ranges | ±100mV to ±20V | | |
| PC Connection | USB2.0 (USB1.1 compatible) | | |

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interfacing and application goal. The total time for my effort was under two hours.

The fact that I went from a collection of devices to a working system in such a short time is a tribute to the easy-to-grasp design of the Supercarrier board, the simplicity of the TTS256 chip (only four signals, plus power and ground, are required), the ability to use serial I/O in all devices, and my own past experience with ZiLOG tools and hardware.

DESIGN CONTEST WINNERS

Now that you have seen what I did with my Z8 Encore! XP development board, take a look at what others are planning on doing. The following readers responded to my November 2005 column's offer of a free Z8 Encore! XP development kit by submitting detailed proposals describing their intended application. Table 1 lists the individuals and brief descriptions of their proposals.

It will be interesting to see these projects become actual working circuits. I wish all the winners the best of luck and hope their interfacing goes smoothly.

While I chose to use my Z8 Encore! XP development board to control the TTS256 and SpeakJet, the BASIC Stamp, PIC, or any other microcontroller with serial I/O will also do the job. The features packed into the TTS256 and SpeakJet should keep the most dedicated hobbyist busy. **NV**

ABOUT THE AUTHOR

James Antonakos is a Professor in the Departments of Electrical Engineering Technology and Computer Studies at Broome Community College, with over 29 years of experience designing digital and analog circuitry and developing software. He is also the author of numerous textbooks on microprocessors, programming, and microcomputer systems. You may reach him at antonakos_j@sunybroome.edu or visit his website at www.sunybroome.edu/~antonakos_j

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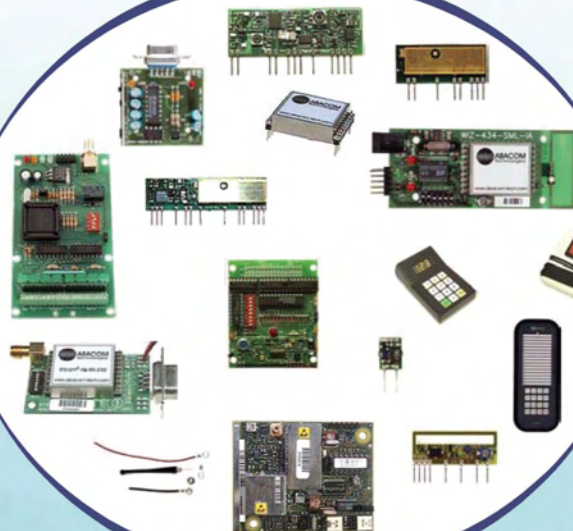
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■ BY L. PAUL VERHAGE

A MARTIAN NEAR SPACE LAUNCH

BALLOONS ARE POTENTIALLY THE BEST way to study large areas of Mars. They can travel across the Martian surface faster than rovers and they won't be stopped by every boulder or canyon that gets in the way. Also, since balloons are closer to the Martian surface than satellites, their cameras resolve far smaller surface features. With this in mind, let's look at what it would take to launch a near spacecraft on Mars. Later, we'll briefly look at launching a near spacecraft on Titan.

Mars Pathfinder Surface Weather Report

7:57 PM PDT August 17, 1997

14:58 Local Mars Time

Pressure: 6.68 mb

Temperature: +3 degrees Fahrenheit

Wind: Light, from the west

mpfwww.jpl.nasa.gov/MPF/science/weather.html

I'll address three factors in this month's column. The first is the surface winds and their effect on filling and launching a weather balloon. The second factor is how the atmospheric composition and pressure on the surface will affect the initial volume of a weather balloon. The last factor is how atmospheric pressure changes with altitude. This factor is important because it determines the maximum altitude that a weather

balloon will reach before bursting.

FILLING A WEATHER BALLOON ON MARS

Refer to the weather report above. When a near space group fills a weather balloon, they prefer a surface wind of zero knots. Since a balloon acts like a kite sail, it blows around even in the slightest wind. A balloon can successfully be filled in winds of a few knots (a knot is equal to 1.15 miles per hour), but the measurement of the balloon's lift is less accurate. This reduction in accuracy is a minor problem, but it does result in a less predictable ascent speed and maximum altitude for the balloon. Wind speeds greater than 10 knots will make filling a balloon nearly impossible and possibly dangerous. If the balloon doesn't bounce around and burst during the

filling, then it will yank the balloon crew around and possibly give someone a string burn as a result.

One benefit of filling a balloon on Mars is that the air pressure is much lower than it is on Earth. This is because the wind creates a force that scales by the square root of the air pressure. This means if the air pressure is reduced by 75% to only one quarter its original pressure, then the wind feels like it's only blowing half (the square root of one quarter) as fast.

Average air pressure on the surface of Mars is just under seven millibars (mb). On Earth at sea level, the average air pressure is 1,013 mb. Therefore, Mars has an atmospheric pressure that is 0.7% that of Earth. So winds on Mars feel like they're only blowing 1/12th as fast as they do on Earth. Satellite measurements indicate that the strongest winds on Mars are between 67 to 111 mph. This means the maximum winds on Mars only feel like they are blowing at between 5.6 to 9.3 mph.

Wind speeds in the range of 100 mph and higher will create dust storms on Mars. During a dust storm, visibili-



■ **FIGURE 1.** Open house at the National Weather Service. It's surprising how many people will line up to look inside a balloon filling shed. And I ought to know, I was one of them.

ties can drop to only a few meters and the dirt will sandblast astronaut's visors. So to safely launch a balloon during a dust storm, astronauts will have to fill the balloon inside of a structure, like a shed. After they finish filling the balloon, they'll carry it outside and release it. This is the same way the National Weather Service fills and launches their radiosondes.

The Mars Pathfinder, which landed on Mars in July 1997, carried a set of wind socks on its ASI/MET mast. Pathfinder's windsock data indicated that the Martian winds are at their strongest from morning to noon and weakest in the late afternoon and early evening.

So it appears astronauts can fill and launch weather balloons on Mars. It will be easier if they wait until after noon local time to fill the balloon. But if they want to launch during a dust storm, they'll need to use a filling shed.

THE COMPOSITION OF THE MARTIAN ATMOSPHERE

Let's assume our astronauts want to launch a four pound (1,816 grams) payload and 6.6 pound (3,000 grams) weather balloon. Mars has a surface gravity that's 38% of Earth's gravity. Therefore, on Mars, the payload will only weigh 1.5 pounds and the balloon 2.5 pounds. For our weather balloon to launch this payload, it must contain enough helium to displace at least four pounds of Martian atmosphere (the

weight of the payload and balloon).

Because gravity affects the weight of air and the payload alike, we won't calculate weights on Mars, but just use mass. So in this case, the balloon must displace an atmospheric mass of at least 4,812 grams before the balloon can begin lifting the payload.

An Avogadro's number of gas molecules at standard temperature and pressure (STP) occupies a volume of 22.4 liters and has a mass that is equal to the gas' atomic weight. Did you get all of that? I guess I should explain a few things about that sentence.

Avogadro's number is 6.022×10^{23} and it's the number of molecules in one mole of any chemical. One mole of a chemical is an amount of that chemical that has a weight in grams that's equal to its atomic mass. So one mole of hydrogen gas weighs two grams, occupies a volume of 22.4 liters at STP, and contains 6.022×10^{23} molecules (remember that hydrogen gas is diatomic, or contains two hydrogen atoms).

Standard temperature and pressure is a temperature of 0 degrees C (or 273 Kelvins) and a pressure of one atmosphere (1,013 mb). A Kelvin is equal to a degree Celsius. The only difference between them is that the Kelvin temperature scale begins at -273 degrees Celsius, or the temperature of absolute zero, while the Celsius scale begins at the freezing point of pure water. The Kelvin temperature scale doesn't use the word "degrees" like Fahrenheit or Celsius. So please say the temperature is 273 Kelvins and not 273 degrees Kelvin.

The Martian atmosphere is 95% CO₂, 3% N₂, and 2% is trace gases. We'll treat the Martian atmosphere as if it were pure carbon dioxide since the nitrogen and other trace gases only affect the density of the Martian atmosphere by a small amount. Since the chemical formula of carbon dioxide is CO₂, its atomic mass is equal to the atomic mass of one carbon atom plus two oxygen atoms. By ignoring isotopes, I calculate the mass of a carbon dioxide molecule to be $(1 \times 12) + (2 \times 16)$, or 44 atomic mass units.

So an atmosphere of pure carbon dioxide has a mass of 44 grams per 22.4 liters at STP. Helium has a mass of four grams per 22.4 liters at STP, so 22.4 liters of helium will displace 40 grams of carbon dioxide at STP. However, the air temperature at the Martian surface is -14 degrees C (259 K) and the pressure is seven millibars. So we must adjust the density of the carbon dioxide atmosphere on Mars.

You probably learned in your high school chemistry class that decreasing the temperature of a fixed amount of gas causes it to contract in volume and that decreasing the air pressure acting on it causes it to expand in volume. The equation used to calculate the volume of a gas outside of STP is:

$$V_f = V_i \times (T_f/273) \times (1013/P_f)$$

where

V_f is the final volume

V_i is the initial volume

T_f is the final temperature

P_f is the final pressure

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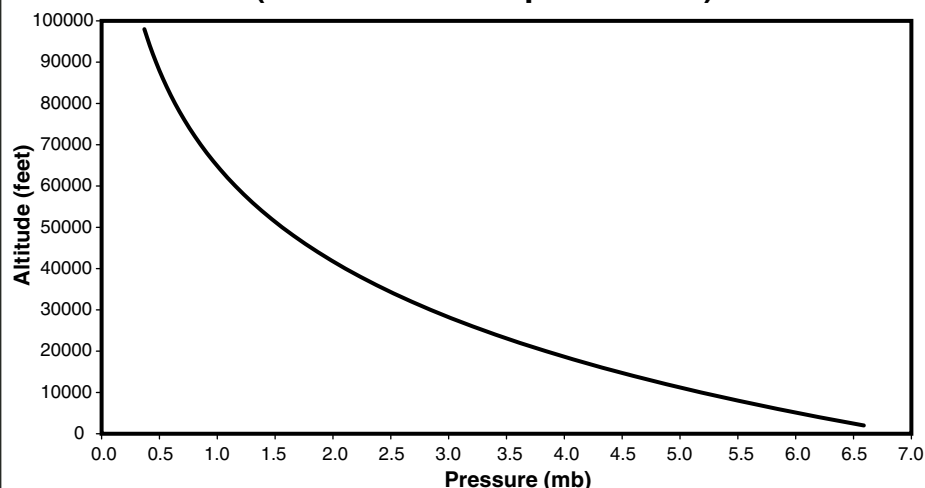


Photograph of the Earth from Near Space, PRICELESS.



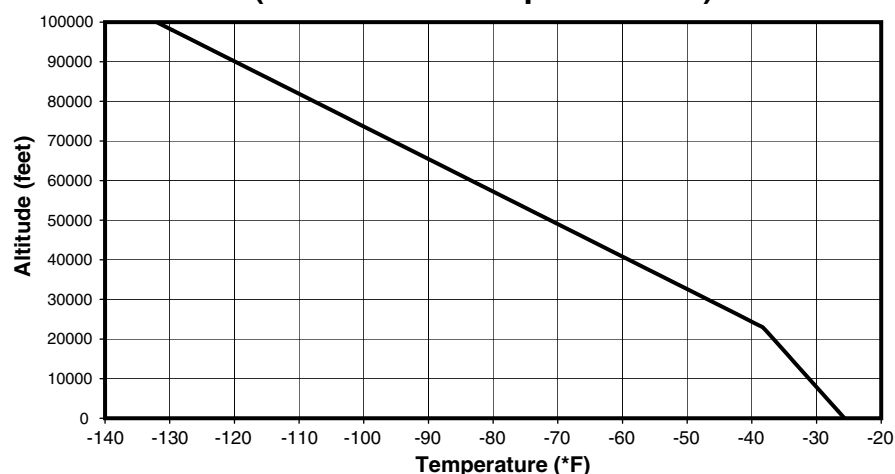
■ FIGURE 2

Air Pressure (Standard Atmosphere Mars)



■ FIGURE 3

Air Temperature (Standard Atmosphere Mars)



Therefore, the volume required to displace 40 grams of a CO₂ atmosphere at Martian temperature and pressure is no longer 22.4 liters but, 22.4 liters * (259/273) * (1013/7) or 3,076 liters (108.6 cubic feet).

To lift our 10.6 pound Earth payload (which is the balloon and payload weight), our astronauts will need to fill the balloon to a volume of 13,066 cubic feet. This is equivalent to a spherical balloon with a radius of 14.6 feet or a diameter of 29.2 feet. This is well within the capabilities of a 3,000 gram balloon which can inflate to a diameter of 42.6 feet before bursting. But before we can actually launch the balloon, the astronauts will need to add a little extra helium

to generate a positive lift. However, we'll ignore that for this article since the additional volume is small compared to the initial volume of the balloon. Now let's have our astronauts release the balloon and watch it climb into the morning skies of Mars.

ATMOSPHERIC STRUCTURE AND MAXIMUM BALLOON ALTITUDE

At the NASA Glenn Research Center (GRC) website, I found the equations describing the air temperature and pressure of the Martian Standard Atmosphere (MSA). The MSA

is a mathematical model describing the average Martian atmosphere as a function of altitude. According to the webpage (listed in the sidebar), the atmospheric pressure of the Martian Standard Atmosphere is calculated by the following equation,

$$P = 14.62 \times e^{(-0.00003 \times H)}$$

where

P is pressure in pounds per square foot (PSF)

H is the height in feet

Personally, I prefer millibars of pressure and feet of altitude. (That sound you just heard was that of an SI purest having a minor heart attack after reading that last sentence.) The atmospheric temperature of the Martian Standard Atmosphere is calculated by:

$$T = -25.68 - 0.000548 \times H$$

(below 22,960 feet)

$$T = 10.34 - 0.001217 \times H$$

(above 22,960 feet)

where

T is the temperature in degrees Fahrenheit

H is the height in feet

These equations were developed by the observations of the Mars Global Surveyor, a spacecraft that is still functioning in orbit around Mars.

Figures 2 and 3 show charts of air pressure and temperature on Mars as a function of altitude that I generated from these equations.

Both air pressure and air temperature will affect the volume of the balloon. So in my spreadsheet, I combined the effects of pressure and temperature into a new column that calculates the volume of the balloon in ratio to its initial volume on the surface. Figure 4 shows the chart from that column in the spreadsheet.

In these charts, I assumed the temperature and pressure of the helium inside the balloon will be the same as the temperature and pressure of the atmosphere outside the balloon. You'll note from the chart that the volume of the balloon begins

to decrease as it approaches 100,000 feet. That surprises me and now I have to wonder how accurate the pressure and temperature equations are at extremely high altitudes. But we'll run with these numbers anyway since we'll see shortly that the weather balloon will never get that high. By the way, the spreadsheets I used to create these charts are available on the *Nuts & Volts* website (www.nutsvolts.com).

According to Kaymont (the company where I purchase my balloons), the maximum volume of a 3,000 gram balloon is 40,479 cubic feet. So our astronauts' 3,000 gram balloon carrying a 1.5 pound payload (under Martian gravity) can expand 40,479/13,066, or three times in volume before bursting. According to my chart then, the balloon will reach an altitude of 48,000 feet before bursting.

That's the same as my lowest altitude near space flight on Earth. The average altitude of my 54 flights (all on Earth unfortunately) is 84,350 feet. So it's apparent that near space flights on Mars are going to be a lot lower than on Earth. This really isn't too surprising though, since the surface pressure on Mars is about the same that we see at an altitude of 103,000 feet on Earth.

Let's quickly test the accuracy of this chart and its conclusions. So as a test, I have created a spreadsheet for the Earth's standard atmosphere and with data that was collected on one of my flights from August 2003. I used the temperature and pressure from both my flight and from the Standard Atmosphere to calculate the diameters of two balloons and developed the chart in Figure 5.

What strikes me the most about this chart is that the balloon volumes follow each other very closely until the balloon reaches 50,000 feet. Above that altitude, the standard atmosphere predicts the balloon will expand faster than my actual flight data indicates.

Why is this? Is the real balloon having difficulty expanding above 50,000 feet? The ascent rate for this flight is constant through the 50,000 foot transition, so the balloon can't be experiencing difficulty in expanding in volume (if it did, the ascent rate would

slow down). Besides, the air pressure changes smoothly throughout the flight, with no abrupt transitions. But there is one thing special about 50,000 feet: the stratosphere begins there (the stratosphere is lower in the winter, but this was a summer flight).

In the troposphere, the air temperature decreases with altitude. But in the stratosphere, the presence of ozone makes the air warmer. There's more solar ultraviolet radiation higher in the stratosphere since it's the ozone that is removing it. Helium doesn't stop any ultraviolet that I know of, so I suspect it's transparent to ultraviolet. Also, the balloon is white and its color may be reflective to the sun's increased ultravi-

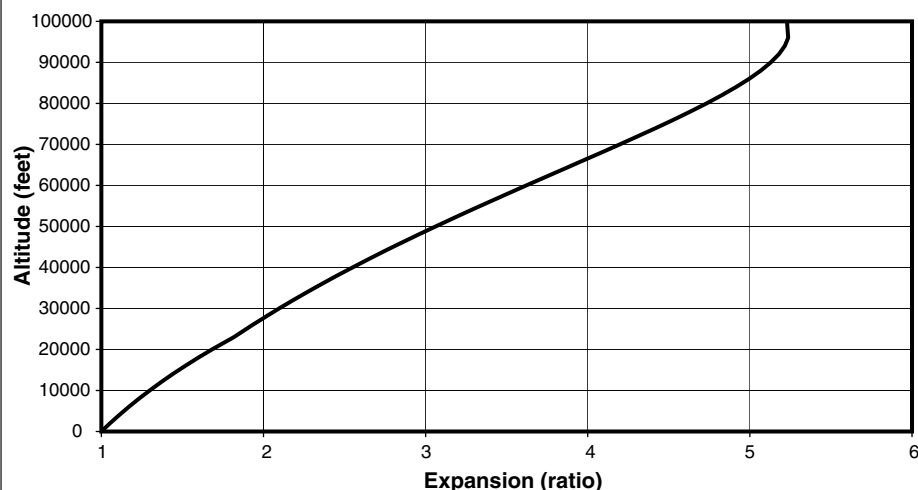
olet radiation. No doubt there are errors in my temperature and pressure sensors. Perhaps my temperature sensor is less accurate at low air pressure. Out of these factors, which prevails?

This calls for an experiment (I love it when missions generate more questions than they answer). In the future, I'll measure the temperature and pressure inside the balloon and compare it to conditions outside the balloon. To further resolve this issue (or perhaps to muddy it further), I'll also record images of the balloon as it ascends. I can then calculate the true volume of the balloon from the diameter of the balloon images.

There are two minor (I hope) errors

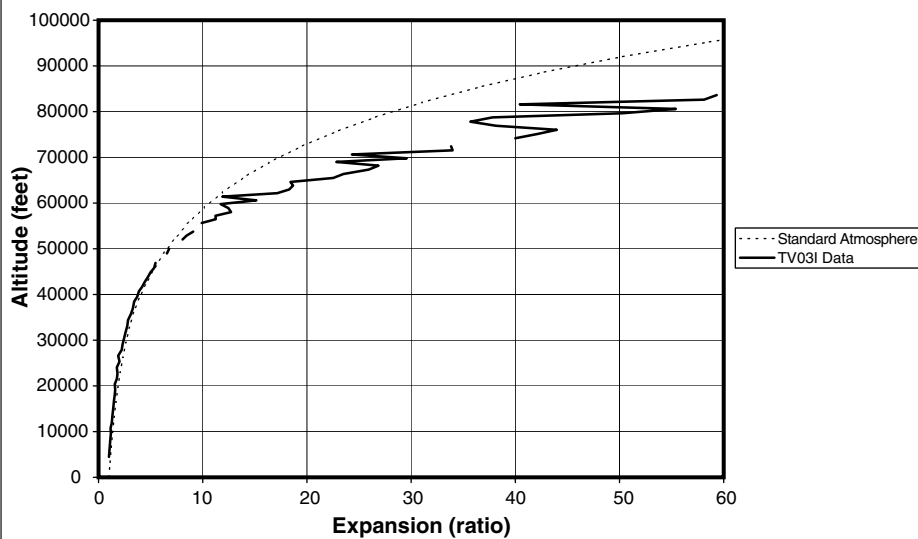
■ FIGURE 4

Balloon Volume (Standard Atmosphere Mars)



■ FIGURE 5

Balloon Volumes



SCALE HEIGHT

The scale height of an atmosphere is an indication of how fast its density decreases with altitude. Just how fast the atmospheric density (pressure also works here) changes with altitude depends on the current atmospheric density. This relationship between rate of change and its current value is also seen in things like interest (how much money your savings account will make this year depends on how much money you have in it at the beginning of the year) and population (how many rabbits you'll raise this year depends on how many rabbits you start the year with). In the mathematics of these kinds of changes, a specific number keeps popping up, the number 2.71828 This number is called e and it is related to rates of change just like π is related to circles.

To make the mathematics simpler, physicists look at how fast the atmospheric density of a moon or planet decreases by a factor of e . The altitude at which this occurs is called the scale height of that atmosphere. On Earth, the scale height is 8.5 kilometers for the average atmosphere at the Earth's surface. For Titan, this number is between 40 and 60 km and for Mars it's 11.1 km. The scale height is also the height of an atmosphere if it had a uniform density equal to its surface pressure. So the top of Earth's atmosphere would be at 8.5 km high if its density didn't decrease with altitude.

The scale height of an atmosphere is affected by the gravity of the moon or planet and the mass of the gas in the atmosphere. Decreasing the gravity of a moon or planet increases the scale height of its atmosphere as does having a lower mass gas in the atmosphere. Having a stronger gravity and/or a denser gas in the atmosphere means the atmosphere is more compressed towards the surface, which means the scale height is lower. The planet Neptune and the moon Titan have roughly the same scale heights, because Neptune's atmosphere is largely hydrogen and helium, and Titan's gravity is so low.

Mass and gravity are not the only things to affect scale height. Changes in temperature also affect the scale height of an atmosphere by causing the gas in an atmosphere to expand or contract. So in general, the scale height of an atmosphere is given at various altitudes and for an average temperature, rather than for the entire atmosphere.

FIGURE 6

Air Temperature (Titan)

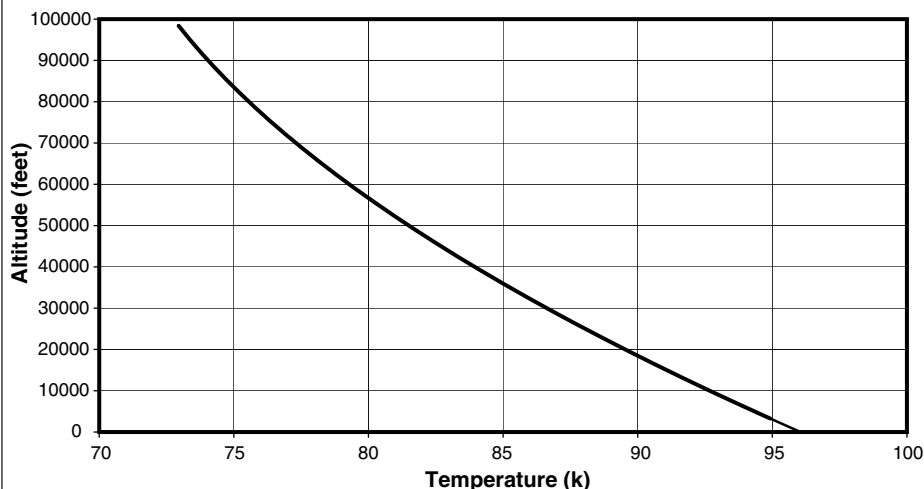
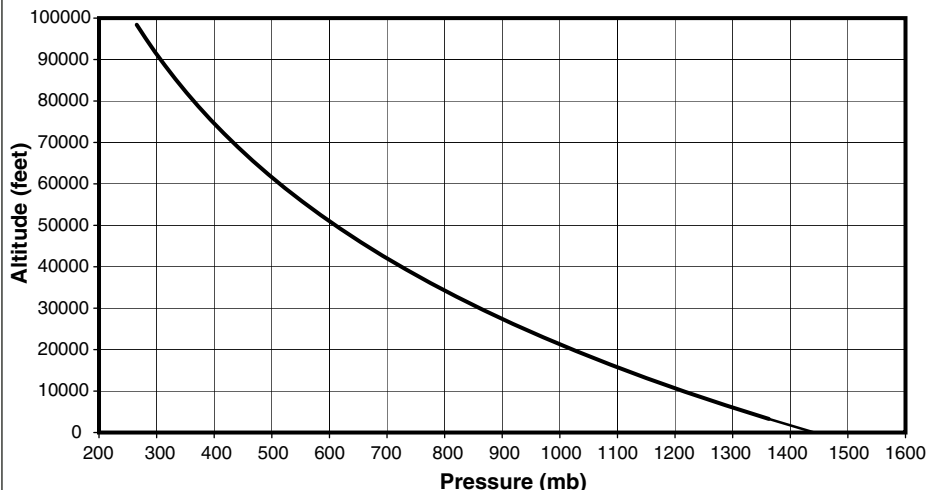


FIGURE 7

Air Pressure (Titan)



that will creep into this volume calculation of the balloon. The first is that the equator of the balloon will rise higher above the camera as the balloon expands. This means the diameter of the balloon will be slightly larger than is indicated in the photographs. The second is that balloon's skin tension will compress the balloon into a smaller volume than air temperature and pressure would like to make it.

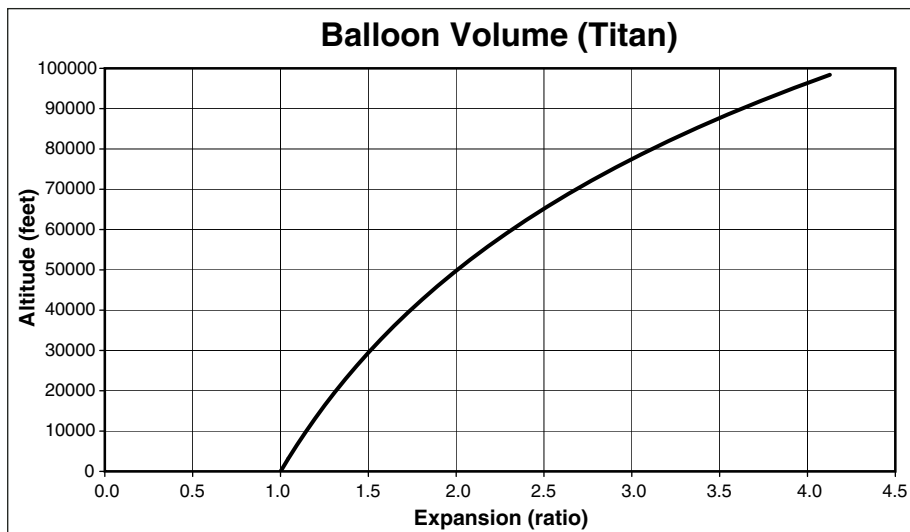
To close out this Martian exercise, I calculated what the balloon would see at 48,000 feet above the Martian surface. First, the horizon will be depressed by 3.8 degrees. In other words, the horizon will be 3.8 degrees lower than it is from the surface of Mars. So from one horizon, over the zenith, to the opposite horizon, the sky will span 187.6 degrees,

rather than the 180 degrees that it does from the surface of Mars.

Second, from the balloon's perspective, the distance to the horizon will be 132 miles away from the point beneath the balloon. On Earth, a balloon at 48,000 feet will see a horizon that is 268 miles away from the point beneath the balloon. The greater distance on Earth is due to Earth's larger diameter and less strongly curved surface.

BALLOONS OVER TITAN

I couldn't find an equation for the standard atmosphere for Titan. So in place of an equation, I took measurements from a chart of Titan temperature and pressure and wrote them into a spreadsheet. I then added a trend-



line to the resulting chart and had Excel determine a sufficiently accurate equation for the standard atmosphere of Titan (see Figures 6 and 7).

One thing you'll notice about these charts is that the atmosphere on Titan becomes thinner more slowly with altitude than it does on Earth (check the sidebar for more information). This is due to Titan's lower gravity, which is something like 16% of Earth's gravity. The rate at which an atmosphere becomes less dense with increasing altitude is referred to as the atmosphere's scale height.

The atmospheric pressure on the surface of Titan is 50% greater than on Earth, or 1,500 mb. The air temperature is 96 Kelvins, or right at the temperature that nitrogen liquefies. The composition of the Titan atmosphere is around 90% nitrogen and 10% trace gasses, like methane. But I'll stick with a 100% nitrogen atmosphere to keep the calculations simple.

The mass of a mole of nitrogen (N_2) is 28 grams. So a mole of helium displaces 24 grams of atmospheric mass. At a surface temperature of 96 Kelvins and pressure of 1,500 mb, I calculate that 5.3 liters of helium gas will displace 24 grams of nitrogen. To lift the 10.6 pound payload (the mass of the balloon and near spacecraft) will require a balloon with a volume of 1,063 liters or 37.5 cubic feet. This implies that a 3,000 gram weather balloon can expand 1,079 times larger before bursting!

In the chart in Figure 8, you can

■ **FIGURE 8.** Titan's thick atmosphere prevents a weather balloon from expanding as much as Earth's thinner atmosphere, so the balloon will rise to a higher altitude before bursting.

see that to climb to an altitude of 100,000 feet above the surface of Titan, the balloon will only expand 4.5 times (compare this to 100 times on Earth). So the maximum volume of the balloon will only need to be 169 cubic feet. A balloon this small is lighter in weight than a 3,000 gram balloon and if we use the smaller balloon, less helium will be needed to begin with.

Indeed, we may find it difficult to prevent the balloon from rising too high in the Titanian atmosphere. Our balloon could easily spend the majority of its flight above the smoggy clouds enshrouding Titan. This would be great for an atmospheric sounding, but it would be a disaster for a mapping mission. **NV**

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Pathfinder Weather Data
mars.sgi.com/ops/asimet.html

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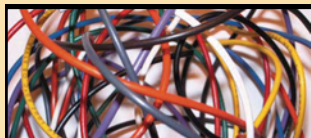
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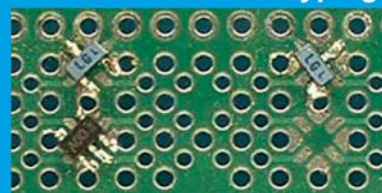
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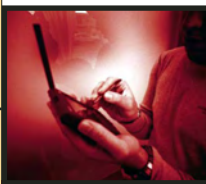


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READER FEEDBACK

Continued from page 6

INTERCEPTING COMMANDS

I have been reading Jon William's article on the Playstation Robot controller. I wanted to contribute my idea for intercepting PS2 commands. I have successfully used this method to intercept the command to put the controller into analog mode.

The PS2 controller interface is a standard SPI interface. I configured an Atmel AVR microcontroller as a SPI slave leaving the I/O ports tri-stated. A short routine reads the SPI data into the SPI data register and transfers the data to the UART to hyper-terminal on my PC. Switching the AVR MISO input between the command and data lines allows the game console data and the controller's response to be viewed. When the action you are trying to replicate occurs, the change in the Command/Data sentence is the command responsible for this action.

Brian Awalt

THIS MAY HERTZ ...

Regarding the answer to the Q&A question "Ghost of a MM5369 Clock" in the January 06 issue ...

In addition to the ELM440 IC replacement for the MM5369 60 Hz generator (NV Jan 06, pg. 14, Craig Kendrick Sellen), Microchip Technology, Inc., has an article published — DS40160A/4_008 — with the title *An Enhanced MM5369 - 60 MHz Generator*. The 60 MHz is obviously wrong and should be 60 Hz, but the article gives all the details to program a PIC12C508 for a 60 Hz and a 1 Hz output.

Duco W. Weytze

SPECIAL INTERESTS?

I am a retired engineer and have been reading or subscribing to your magazine for as long you have been publishing and I have to agree with Ruben Lara in your December issue Reader Feedback. It appears to me that the computer geeks and robotics geeks have taken over your magazine to the exclusion of us experimenters and project construction enthusiasts who like to build simple analog and digital circuits.

I do not know how to program Stamps and have no desire in the future really to learn. I also can see no practical value on how to build a electronically run Dremel tool as a milling machine.

One of the things that originally caused me to read your magazine was the circuit design information and drawings for various simple apparatus and fun gadgets to build. I especially like TJ Byers' Q & A and that is primarily why I keep taking your magazine. Don't let the special interests ruin what was a terrific magazine.

Harry J. Kennedy

TETSUJIN 2006 @ ROBOlympics

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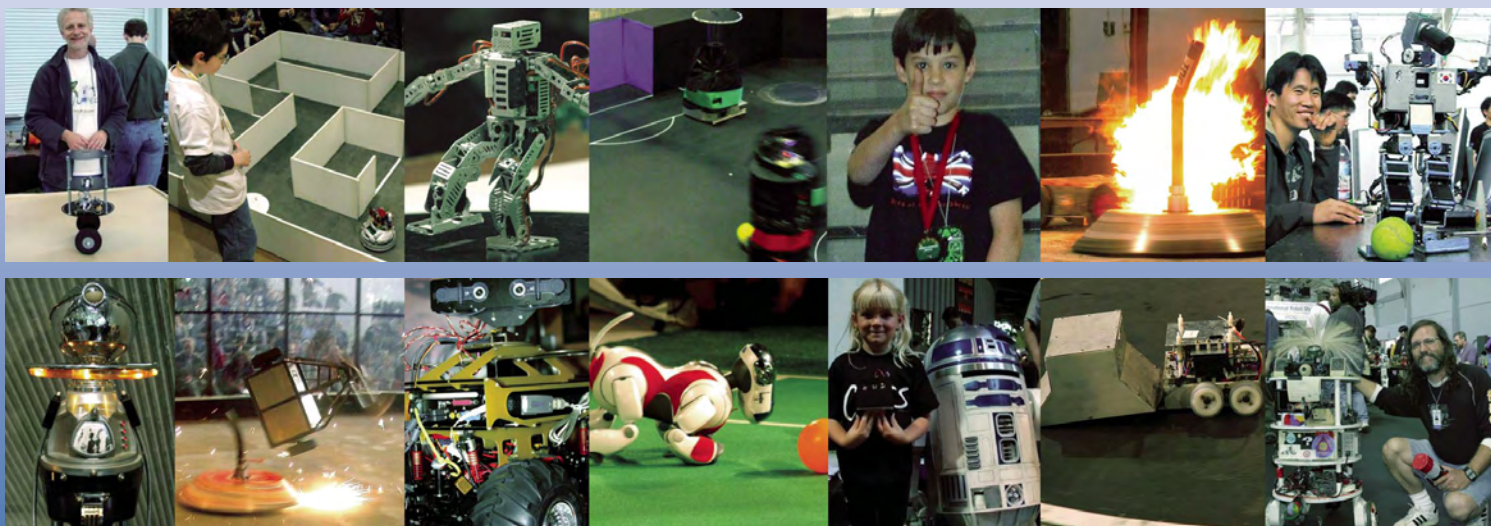
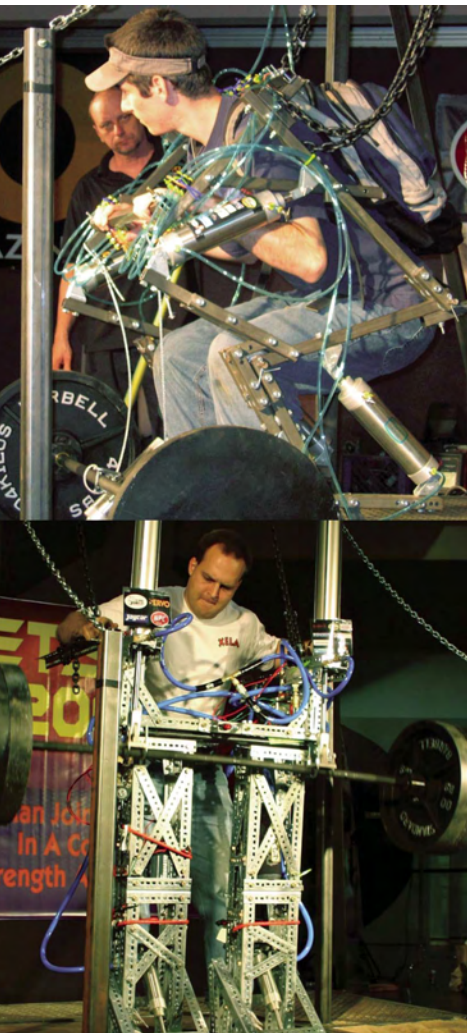
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- ② Electronic Theory
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>>> QUESTIONS

I am plagued with trying to determine when my oil burner ignition transformers have died. These step-up transformers generate 9,300 VAC at about 25 mA (new style electronic types aren't a problem: they die dead). In the old days, I used to test them by shorting a screwdriver across the secondary to see if the sparks came from the screwdriver blade or from broken down insulation on the secondary winding (been knocked off my bucket a few times, but not dead yet!) Then they drop to 6-7 kVAC output, and will not reliably ignite the oil burner (though will still ohm out correctly). Does anyone have a good circuit (read: simple and cheap) that can load these and give me a go/no go reading on their efficacy?

#3061

Anonymous
via Internet

I am currently interfacing my PIC project to several mains relays using an opto-isolated triac (with zero crossing). The current draw required by the mains relay is only 11 mA and the opto-isolated triac is rated at 100 mA. I am currently using the interface and it works perfectly with no heat from the ICs.

My question is: Do I need to use zero crossing for relay control? And, I

keep hearing about a snubber circuit for inductive loads. Do I really need to use a snubber circuit for just a relay? If so, what would be the simplest design?

In the meantime I will continue to use my interface as it works fine.

#3062

Paul Webley
Ireland

I need cross references to standard part numbers for these RadioShack transistors. RadioShack's website was a lost cause.

NPN, RS2010, Silicon, High Gain,
276-2010

PNP, RS2034, Silicon, General
Purpose, 276-2034

NPN, RS2042, Silicon, Power,
Darlington, 276-2042

#3063

James Tadlock
Española, NM
mr_tadlock@hotmail.com

>>>> ANSWERS

[#1061 - January 2006]

I have six six-volt batteries wired in series to achieve 36 volts. I have tapped the neg to the pos across two batteries and got 12 volts.

Can I wire all three (sets of two) and get 12 volts with lots of amps and run a large inverter? That would be running series and parallel in one operation. I would have to be using both sources at

the same time. Maybe switches would work?

#1 To safely and efficiently use your 36 volt battery "pack" to run an inverter, you might consider a DC to DC converter. "Solar Converters, Inc." (519-824-5272) www.solarconverters.com/ sells Model EQ 12/36-50 that puts out 12 volts regulated DC at 50 amps from a 36 volt DC input. Also check out www.jameco.com Catalog Part #217269CC which takes 19-36 volts DC input and puts out 12 volts @ 12.5 amps.

Bob Lindstrom, Broomfield, CO

#2 Yes, you can wire the six batteries in series-parallel to obtain 12 volts with lots of amps. You can either parallel three sets of two batteries (in series) each, or else connect in series two sets of three batteries (in parallel) each.

Yes, you can use some form of multipole switching to change from a 36V array (series) to a 12V one (series-parallel).

What you will not be able to do is to use the two voltages at the same time: The switch will be in either the "36V" position or in the "12V" one.

Also, to charge the batteries the switch should be in one of the two positions (according to the charger's voltage and current). To prevent accidents, you will have to add one pole to your switch so that the charger won't be connected if the batteries are in the "wrong" configuration.

And, of course, the switch should be rated for the system's voltage and current. To open a DC circuit – even at moderate voltages like 36V – is no easy job.

If you want to run your 36V loads and an inverter simultaneously, you should get an inverter that runs on 36V. It will be not only easier to connect, but it will use thinner wires and be more efficient.

*Ernesto Cerfoglio
Buenos Aires, Argentina*

[#1063 - January 2006]

I have a digital caliper. I would like it to display measurements in a third way besides inches and millimeters. Are there digital calipers

that have generic microcontrollers that could be reprogrammed or replaced with my own programming? If one of them has something like a generic PIC in it, then maybe ...

Many digital calipers have a data port hidden under a small cover. You can interface the caliper to a desktop computer using an appropriate cable (ex. Mitutoyo Connecting Cable #905409 www.mitutoyo.com) and a converter box (ex. Smart Cable #200-50R9F www.qualityonsale.com). This can be an expensive proposition given the cost of the cable is around \$40.00 and the cost of the converter box is around \$170.00. The good news is that the converter box information comes with a sample Qbasic program that illustrates how to read the caliper value and display it on the screen. Good luck.

*Bill Ryder
Victoria, MN*

[#1062 - January 2006]

I have searched for the Data Sheet on TI's TMS9916NL chip. Any help would be appreciated.

#1 The TMS9916 is from Texas Instruments, and it's part of their 9900 series (circa 1978). The 9916 is a Magnetic Bubble Memory controller.

The following link provides a brief discussion on the part and its use: www.decodesystems.com/tib0203.html

Briefly, Bubble memory was the first attempt to create RAM that would retain its data after power was removed; a sort of very early Flash memory.

*Joe O'Brien
Ladera Ranch, CA*

#2 I contacted TI tech support; they were very helpful and found this 25 year old data sheet, which I have posted at: <http://us.share.geocities.com/russlk/tms9916.pdf>.

*Russell Kincaid
Milford, NH*

[#2061 - February 2006]

Last Fall, we put up a new RadioShack long range VHF/UHF VU-190 antenna and rotator.

Correction

There was an error in the parts list of my answer (in the January issue) to the Aquarium pump turn off issue. The value of R1 should be 330K, not 3.3K.

The corrected parts list:

C1 1000 uF 25V

D1 1N4001

K1 Omron G6RN-1-DC12 (Mouser P/N 653-G6RN-1-DC12)

Q1 2N6427 NPN Darlington (Mouser P/N 512-2N6427)

R1 330K

R2 680K

S1 Push button momentary switch

*Ed Schick
Harrison, NY*

Around April or May, I noticed that the reception for the higher numbered UHF channels seemed to be getting worse. During Summer, this problem seemed to worsen.

Thinking about it carefully now, last Fall we got good to fair reception on channels 36 and 29 and excellent reception on channels 23, 19, and 17. Now it has changed to fair reception on channel 23 and passable on 17. All the others are basically unusable. Clearly, something has changed as the temperature and weather are similar now to when the antenna was installed.

VHF reception has not changed since installation and remains very good.

#1 You have a bad case of high frequency loss. It is important that you start methodically checking only one suspected part at a time. Here are possible trouble spots: You might have a bad "F" connector at the matching transformer, or the RTV rubber has developed a hairline crack around the coax connector or around the twin lead pigtail on the transformer, letting in water. Silicone does not stick very well to most plastics. Also, with binoculars, look at the connections at the antenna terminal block and the antenna element insulators. Is there any debris such as cobwebs, bird droppings, etc? How old is the coax? If you used the old stuff, dirt or corrosion at the "F"

connector could act like a sponge for moisture. Inspect the full length of the coax for any place the insulation could have been cracked or rubbed off from wind motion. One tiny pin-hole could be the culprit. Are there any new kinks in the cable? Any new splices? High numbered channels don't like sharp bends. Bad or leaking splices can act as RF filters. Check the lightning arrestor. Unscrew the coax and temporarily screw in an "F" splicer in its place to see if the arrestor is not partially shorting out. You might temporarily hook up your old antenna (on the ground) and see if the high channels are getting through the distribution amplifier. Lastly, your new antenna could have become defective. I have serviced many antenna systems and these suggestions cover places where I have found trouble.

*Merv Fulton
Tulare, CA*

#2 This problem is similar to my experience with a popular consumer level 10 element FM broadcast receive antenna. My antenna also worked fine for about three months and then the signal level began to fade. After 10 months, the antenna couldn't reliably receive a distant FM station that it was intended to receive. When taken off of the tower and inspected, I found that corrosion had set in resulting in over 30K ohm between the first driven element and

the third driven element and over 1M ohm between the first driven element and the fifth driven element. The cause of the problem was steel rivets which attach the driven elements to insulators on the boom of the antenna and also attach to aluminum jumpers connecting each driven element to the next. This resulted in a series of nine corroded connections between the feed point and the last driven element on each side of the antenna. I had to replace this antenna for my employer with a professional model, but I was able to salvage the corroded antenna for use at my home. I used aluminum wire from a local hardware store in a wrap to bond the driven elements to the aluminum jumpers that connect between each. Take your antenna down and use an ohmmeter to determine if there is any resistance between active elements. The aluminum wire fix is a good one. Small gauge aluminum wire is the best to use and it doesn't hurt to brush the elements and jumpers with emery cloth before wrapping the wire on it.

*Mike Heilman
Monmouth County, NJ*

#3 I looked up the VU 190 antenna, it looked identical to the Channel Master that I recently bought. I took mine out of the box and checked the fastenings; they are steel. I guarantee that the problem is corrosion. My

antenna is covered with grease, so the manufacturer knew it was subject to corrosion and did not want it to show before I got it installed. I don't think I will even put this antenna up. It is not going to last 17 years like the last one.

*Russ Kincaid
Milford, NH*

#4 I would strongly suspect that the balun transformer and/or coax has gradually absorbed water, causing an attenuation of the signal. This would affect high frequency signals more than lower frequencies, and would get worse as more water is absorbed.

The outer braid of coax will act like a wick, so a small break in the insulation (or at the connector) can cause a large amount of water to be sucked into the cable.

My guess is that when the antenna was replaced, the appropriate steps were not taken to seal the connection between the balun transformer and the coax. Alternatively, the balun could be defective and water may have seeped into it.

The coax would be my first choice. Gradually, as a greater and greater amount of water seeps in, the performance of the cable is degrading.

RG-6 is not much more than



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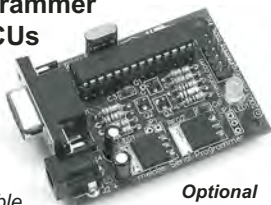
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RG-59, and offers noticeably better resolution on analog video signals. Therefore, replacing the cable would be beneficial in any case. If I were you, I'd replace the coax. I'd pick up a spare balun too, and if the new coax does not immediately solve the problem, replace the balun as well.

You will then want to carefully seal the connection between the coax and the balun transformer. The best method is to use a product called "coax seal." This is a rubbery material that is putty-like. It sticks to itself to form a continuous layer of protection a short time after installation. You'll want to start at the coax and make sure at least 1/2" of cable is covered. Proceed with an overlapping spiral wrap up to the balun, with the coax seal at least covering the threads on the connector of the balun, and preferably overlapping onto the body of the balun. This offers much better protection against water than the rubber boot often provided with new baluns.

Alternatively, you can tightly rap the coax and balun with multiple overlapping layers of black electrical tape. Start at the coax and wrap at least an inch of the coax and with tight overlapping wraps cover all the way up onto to the body of the balun. Next do a second layer starting at the balun and wrapping in the opposite direction. This layer should begin and extend further than the first wrap. Do a third layer using the same technique.

I'd also advise that you arrange the coax and balun so that water drips away from them. Typically, this means making a "drip loop" so that the low point is a loop of coax. This will serve to draw water away from the connector and act as an additional preventative measure to prevent your new coax from being ruined. When arranging your drip loop, do not use wire ties to hold the cable in place as ultraviolet light will cause them to fail after a few years. Better to use speaker wire or something similar (solid copper wire is perfect for this, but use insulated wire to prevent eventual damage to the coax from chafing).

Best of luck. There is nothing like getting crystal clear free reception by

installing a good antenna system.

*Rolf Taylor
Cleveland Hts, OH*

[#2063 - February 2006]

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*Russ Kincaid
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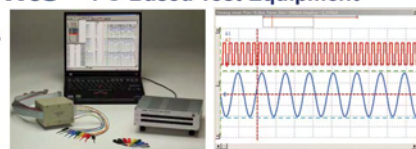


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Triple Output Bench Power Supplies

with Large LCD Displays

Output: 0-30VDC x 2 @ 3 or 5 Amps
& 1ea. fixed output @ 5VDC@3A
Source Effect: $5 \times 10^{-4} = 2mV$
Load Effect: $5 \times 10^{-4} = 2mV$
Ripple Coefficient: $< 250uV$
Stepped Current: 30mA +/- 1mA
Input Voltage: 110VAC



CSI3003X3: 0-30VDCx2 @3A \$179.00 5+: \$169.00

CSI3005XIII: 0-30VDCx2 @5A \$219.00 5+: \$209.00

Details at Web Site > Test Equipment > Power Supplies

NEW!

Premier Repairing System w/Power Supply

Microprocessor controlled design that provides stability and precision of temperature and airflow settings during the rework process. A full digital display of temperature and power source make everything clear to the user while the unit provides vast flexibility at the rework station with the built-in adjustable power supply that provides 0-15V and 2A of power. Hot air soldering and adjustment of temperature are controlled by a micro chip and sensor thus giving tremendous accuracy and reliability.

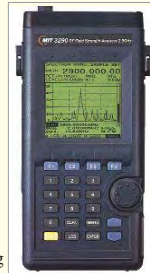
Item# **CSI768****Only \$289.00!**

- Iron Output Voltage: 24V / 35W
- Temperature Range: 100-480°C / 212-896°F
- DC Power Supply: 0-15V / 2A

Details at Web Site > Soldering Equipment & Supplies

2.9GHz RF Field Strength Analyzer

The **3290** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2900MHz. The 3290 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones, Cordless phones, paging systems, cable & Satellite TV as well as antenna installations. May also be used to locate hidden cameras using RF transmissions.

Item# **3290**

Details at Web Site > Test Equipment > RF Test Equipment

Fantastic Low Price: \$1899.00!

- WFM/NFM/AM/SSB modulated signals may be measured.
- Signal Levels up to 160Channels can be displayed simultaneously on the LCD
- PLL tuning system for precise frequency measurement and tuning
- Built-in Frequency Counter
- LED Backlight LCD (192x192 dots)
- All functions are menu selected.
- RS232C with software for PC & printer interface
- Built-in speaker

(Includes Antenna)**B&W Pinhole Bullet Camera w/ 1/3" CCD**

- Weather Resistant Housing
- Signal System: EIA
- Image Sensor: 1/3" CCD Bullet Hole
- Effective Pixels: 510 x 492
- Horizontal Resolution: 380TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-305CP****1-4:\$49.00
5+:\$46.00**

Details at Web Site

> Miniature Cameras (Board, Bullet, Mini's, B/W, Color)

**Butane Portable Soldering Iron & Kit****NEW!**

- Electronic Instant Ignition System
- Naked Flame Burner: Temp to 1300°C/2370°F
- Flameless Burner: up to 400°C/750°F

Two-Piece Iron comes with Solder Tip.

- Equipped with U.S. CPSC Approval Child Safety Standard
- Electronic Instant Ignition System
- Naked Flame Welding: Temp to 1300°C/2370°F
- Soldering Temp: up to 500°C/930°F
- Heat Shrinking: up to 500°C/930°F
- Hot cutting of plastic sheets or plates

- ① Main Unit
- ② Cap
- ③ Solder Dispenser
- ④ Clean Sponge
- ⑤ Siren Wrench
- ⑥ Tress Wrench
- ⑦ Reflector
- ⑧ Hot Knife
- ⑨ 3.5mm Chisel Tip
- ⑩ 3mm Diagonal Tip

**RK3212: Solder Iron \$14.95****RK3124: Solder Kit \$34.00**

Details at Web Site > Soldering Equipment & Supplies > Soldering Irons

Digital Storage Oscilloscope Module

PC based Digital Storage Oscilloscope, 200MHz 5GS/s equiv. sampling USB interface

Convert any PC with USB interface to a high performance Digital Storage Oscilloscope. This is a sophisticated PC based scope adaptor providing performance compatible to mid/high level stand alone products costing much more! Comes with two probes.

Details & Software Download at Web Site

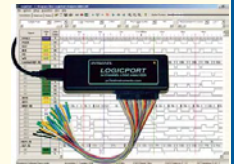
Price Breakthrough!

> Test Equipment > Oscilloscopes/Outstanding Prices

Item# **200DSO** Only **\$749.00****LogicPort Logic Analyzer****\$369.00!**

The LogicPort provides 34 sampled channels including two state-mode clock inputs. It connects to your PC's USB port for ultimate convenience and performance.

- 34 Channels
- 500MHz Timing mode sample rate
- 200MHz State mode sample rate
- Real-time Sample Compression
- Multi-level trigger
- +6V to -6V Adjustable Threshold

Item# **LOGICPORT**

Details at Web Site > Test Equipment > Logic Analyzers

Plug-In Switching Power Supplies

These 15W switching power supplies are an inexpensive way to power devices with robust regulated power and low ripple noise. The low-profile design allow you insert them into a power strip without losing any of the other plugs. Designed with an energy efficient switching technology, the **Universal AC input works from 90-264VAC** with no minimum load required and a 100% burn-in test to ensure they will perform as stated right out of the box. They come with a 1.8 meter output cord and a 5.5 x 2.1mm female plug. UL and cUL approved.



| Item# | Description |
|------------|----------------------|
| 3A-161WU05 | 5 Volts / 2.6 Amps |
| 3A-161WU06 | 6 Volts / 2.5 Amps |
| 3A-161WU09 | 9 Volts / 1.70 Amps |
| 3A-161WU12 | 12 Volts / 1.25 Amps |
| 3A-161WU18 | 18 Volts / 0.84 Amps |
| 3A-161WU24 | 24 Volts / 0.63 Amps |

| Each | 10+ | 25+ | 100+ |
|--------|--------|--------|--------|
| \$9.95 | \$8.95 | \$8.49 | \$6.95 |

Details at Web Site > Test Equipment > Power Supplies

SONY Super HAD CCD Color Weatherproof IR Cameras

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 480TV lines
- Min. Illumination: 0Lux

Item# **VC-827D** 1-4:\$149.00 5+:\$139.00**SONY Super HAD CCD B/W Weatherproof IR Camera**

- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-317D** 1-4:\$69.00 5+:\$65.00**SONY Super HAD CCD™ equipped camera's feature dramatically improved light sensitivity****SONY Super HAD CCD Color Camera**

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-805** 1-4:\$69.00 5+:\$65.00

Details at Web Site

> Miniature Cameras (Board, Bullet, Mini's, B/W, Color)

SONY Super HAD CCD Color Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-819D**
1-4:\$89.00 5+:\$79.00**SONY Super HAD CCD Mini B/W Board Camera**

- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV Lines
- Min. Illumination: .05Lux/F1.2

Item# **VC-103** 1-4:\$33.00 5+:\$29.00

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ www.CircuitSpecialists.com. PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors, miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCB fabrication, educational D.I.Y. kits, cooling fans, heat shrink, cable ties & other wire handling items, hand tools for electronics, breadboards, trainers, programmers & much much more! **Some Deals you won't believe!**

Circuit Specialists, Inc. 220 S. Country Club Dr., Mesa, AZ 85210

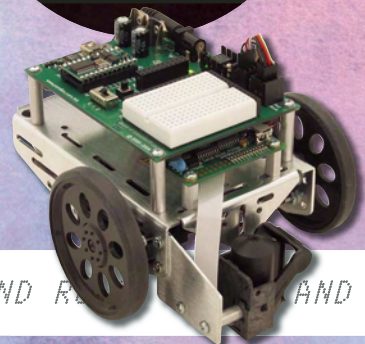
800-528-1417 / 480-464-2485 / FAX: 480-464-5824

Serial Inkjet Printer Kit

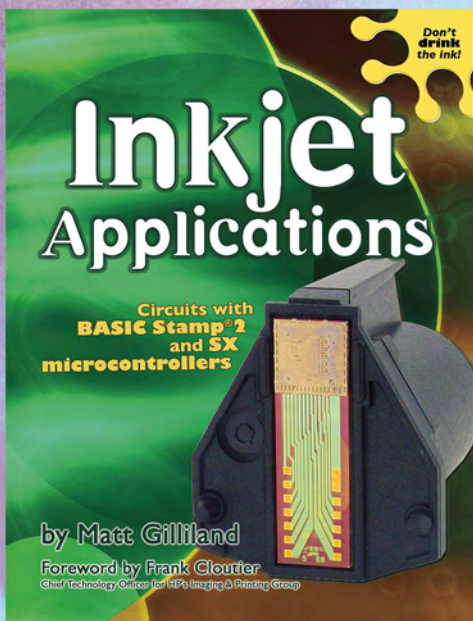
Includes
Boe-Bot® mounting
hardware!

\$99.95
#27949

Want to learn about inkjet printer technology? Want to print text with a robot or by waving an inkjet nozzle over a piece of paper? Parallax, Hewlett-Packard Specialty Printing Systems, and Matt Gilliland have combined to produce this unique kit. The hardware and documentation are designed around HP's Thermal Inkjet 1.0 technology. Using the Parallax Serial Inkjet Printer board, your microcontroller sends a string of serial data which is printed as 1/8" tall characters. Waving the inkjet cartridge over a piece of paper or mounting it on a Boe-Bot produces print-quality text in the font of your choice! Boe-Bot Robot Kit sold separately (Serial #28132; USB #28832) for \$179.00.



PRINT AND ROLL! PRINT AND ROLL! PRINT AND ROLL!



PARALLAX Z

www.parallax.com

Order online or call our Sales Department toll-free at 888-512-1024 (Mon-Fri; 7am-5pm, PT). Boe-Bot is a registered trademark of Parallax, Inc.



INKJET APPLICATION CONTEST:

Using a microcontroller to fire an HP inkjet, enter your project in our 2006 HP and Parallax Inkjet Application Contest. The three categories include Porous Media, Art, and Mechanical Control. Four prize levels are available within each category. Prize values total over \$3,000! This contest ends on June 15, 2006. All details are provided at www.parallax.com.

If you would like to participate in the 2006 HP and Parallax Inkjet Application contest, you must obtain a Project Number from Parallax to attach to your submittal. The issuance of a Project Number represents a commitment on your behalf to submit a project in the contest. Project Number requests may be submitted until May 31, 2006.

PRIZES IN EACH CATEGORY INCLUDE:

1st



Photosmart 3310 Printers

2nd



Photosmart R717 Digital Cameras

3rd



Photosmart 385 Printers

4th



Parallax Professional Development Boards